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THE CHEMICAL WORLD

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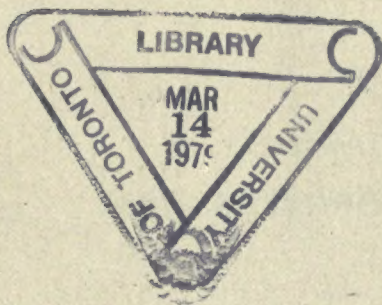
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OF
CHEMISTRY AND CHEMICAL ENGINEERING

EDITED BY
W. P. DREAPER, F.I.C.

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"Science moves, but slowly, slowly creeping on from point to point."—TENNYSON.

VOL. II. No. 1.

JANUARY, 1913.

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THE INDUSTRIALIST.

THE remarks of the past President of the Society of Chemical Industry at the New York meeting (CHEMICAL WORLD, 1912, I, 390) again draw attention to the nature of the teaching which should be imparted to the chemical students in our colleges. There is little doubt but that a good deal of difficulty still exists in certain quarters in determining the best course of study for the average student. The problem is complicated by the uncertainty connected with the absence of a generally accepted standard to represent the minimum educational requirements of a chemist.

When a man knows beforehand that his future life's work will be intimately connected with a certain industry, he sometimes enters at a technical college or school and obtains a knowledge in outline of chemistry, and some other branches of science, as applied to certain industries. He leaves college at the end of a two years' course, with a knowledge of certain principles which will be of definite value to him in his future work.

But is this man in the broad sense of the term a chemist, any more than a dentist is a doctor? He has had no time to master chemistry in its general sense, and can only claim special knowledge, which has been gained under conditions mapped out to meet certain vocational requirements. The question is open to argument.

On the Continent no such claim would, in the nature of things, be put forward. A man possessing such a knowledge in addition to a sound commercial training would expect to utilise it in a more general manner. He might become an industrialist, possessing a knowledge of chemistry which would be considered part of the ordinary stock-in-trade of the head of a factory, or manager in an industrial concern. In England he would probably call himself a chemist. On the Continent he would claim to have some knowledge of chemistry.

This difference is one which should be realised, for the chief value of such a technical training is of a secondary order from a chemical point of view. The man who has a thorough knowledge of chemistry

which will qualify him in research (which may, or may not, be confirmed by a University degree or the equivalent qualification of a recognised examining body) should alone be considered a chemist.

If this position is realised and accepted, an estimation of the relative value of a University training and that obtained at a technical college may be possible.

The industrialist will be an increasingly essential factor in future progress and general advance in industry. The position of the chemist in many cases must depend to a large extent upon the scientific knowledge which is possessed by the former and the general public. This is undoubtedly one reason why this point is more definitely recognised where the heads of firms are highly trained industrialists, having received in the course of their general education a knowledge of chemistry and scientific methods.

The fact that the term "industrialist" is rarely met with on this side of the water is one for regret, for its use indicates that those in authority have, in addition to an ordinary commercial education, a definite knowledge of such matters, and can make use of it in the control and regulation of industrial affairs.

It is evident that relations between the manufacturer and chemist cannot fail to be more satisfactory where such conditions exist.

We do not know of any institution in this country which offers a training on the lines indicated; that is to say, one that has established a department for the training of industrialists on an adequate scale. Such a department must succeed, or fail, on the quality of the men who would pass through it. General factors are involved, which are collectively present in comparatively rare cases. Heredity, general education, certain difficultly defined personal qualifications, are obviously essential factors in the production of this modern product. One day this will be more fully recognised, and then we shall hear less about the want of a more definite lead in such matters, which is surely the least that the workers in a modern State may expect and claim from their industrial leaders.

Greeting from the Past.

Even to-day we are unable to state definitely whether alcohol is, or is not, harmful in its use, when taken in the diluted form generally present in alcoholic beverages. This points once more to the extremely empirical nature of our knowledge in certain directions. It is interesting to note in a recent address given by such an authority on the medical side as Charles Mercier, M.D., F.R.C.P. (*Lancet*, 1912, p. 1492), that the nation is rapidly becoming more sober. The description given of life in the latter part of the eighteenth century is interesting. After dinner the scene is described as follows:—

"The decanters went round in coasters on the polished mahogany. After a decent interval, the stories began to broaden, and the ladies retired, while the gentlemen settled down to the business of the evening. From that time until midnight, drinking went on; not rapid or furious drinking, but slow and steady absorption, as the decanters went round.

"At length the orgie came to an end, and the half-drunken servants staggered in to carry their wholly drunken masters to bed."

A further description extends the picture to the conditions of everyday life:—

"The doctor was often half seas over when he attended his drunken patient; the parson was often drunk in the pulpit; judge, counsel, and the attorneys pursued their avocations in court in a prevailing atmosphere of hot coppers. The Prime Minister went drunk to the House of Commons, where he was attacked by the leader of the Opposition, also drunk, while order was kept by a Speaker who was half seas over. There was no excise on spirits, and the coarser kinds of distilled liquors were ridiculously cheap. As you passed along the bye streets of London, and perhaps of other great cities, you might read the legend hung out over the drink cellars, 'Here you may get drunk for a penny; dead drunk and clean straw for twopence.'"

It is difficult to realise the improvement which has taken place during the interval. This is summed up in his own words:—

"The English are now a sober nation. If we consider the altered conditions of life and of employment, we see that this must be so. The occupations by which men now earn their living require a skill, a nicety, a vigilance, an accuracy, an attention, which are incompatible with even occasional drunkenness. Even in the lowest ranks of labour, among navvies, dockers, and day labourers, sobriety is the rule, drunkenness the rare exception."

This distinguished physician has hopes for the future. He speaks in optimistic terms:—

"I find that with the sole exception of printing, every great mother invention, the fruitful parent of scores of others, such as steam, electro-magnetism, the gas engine, was made by an Englishman. I find that every country in the world comes to England for its live stock. Where is the evidence of decadence and decrepitude?"

In reply to the question, "Why do people take alcohol?" he is explicit. He frankly upholds its use under modern conditions for the average person:

"Alcohol has the power to unlock the store of energy that exists in the brain, and to render available, for immediate expenditure, energy that without its use would remain in store, unavailable for our immediate needs.

"Though alcohol is not itself a food, it does without the slightest doubt enable many people to assimilate and digest food that without its aid would be unavailable to them. I do not pretend that this is the most important function of alcohol; but it is indisputably a function, and a useful one."

So far so good, but it is unfortunate that the evidence of actual value available is not of a more definite order. A great deal of time is evidently wasted under present conditions on false advocacy on one side or the other. Perhaps the bio-chemist may ultimately solve the problem.

The "Central."

This month witnesses the transfer of the Chemical Department of the City and Guilds Central College to the Imperial College of Science and Technology. It is impossible to let the occasion pass without some comment on the part this department, under the able direction of Professor H. E. Armstrong, has played in the progress of modern chemistry in this country.

Elsewhere the matter is dealt with in more detail (p. 13), but we cannot refrain from extending to Professor Armstrong every good wish in his future life's work. That the "school" of chemistry he has created in this country can suddenly come to an end, is impossible. The work may be carried on elsewhere, but his past students remain, diffusing, in their turn, an enthusiasm based on a firm belief in their teacher's methods.

Thus it is evident that the work of the "Central" will remain, and that Professor Armstrong in his retirement from actual teaching—if this is his intention—will surely realise that the train he started has not been extinguished; that his past students carry the torch into many a dark place; that his methods have been realised and adopted in many cases where progress is achieved. It is seldom that a man can claim as much as this. Any words that we can add must be of small account by the side of actual achievement.

Professor Armstrong has been a hard hitter where he deemed it necessary. In this he may not always have been right. What man could claim such a distinction? But we are certain that no chemist in this country has anything but praise for the work which has been accomplished, or a word to say against his honesty of purpose, which has been obvious to all. It is difficult to fully realise the changes which have come about during the last thirty years in methods. That Professor Armstrong has taken an important share in the same is generally acknowledged. The "Central" Chemical Department may in due course become a tradition. Time may be required for its value to be properly realised. It has directly and indirectly played its part in bringing about a change in methods which has rendered it possible for students to obtain a thorough training in chemistry without leaving this country.

THE PERMANENT "GROWTH" OF CAST IRONS AFTER REPEATED HEATINGS: ITS CAUSES AND POSSIBLE REMEDIES.

By PROFESSOR H. C. H. CARPENTER, University of Manchester.

(Continued from Vol. I., page 293.)

PART II.—Suggested Remedies.

THE investigations described in the previous article lead to the conclusion that there is no such thing as a grey iron which will not grow either when repeatedly heated to redness in contact with furnace gases, or air, or superheated steam, in the absence of a medium which would protect the iron from their direct action. A possible way of overcoming this difficulty which immediately suggests itself is to coat the iron with a suitable enamel. This enamel would have to fulfil the following conditions: it would require to have the same coefficient of expansion as the iron, to adhere firmly to it at all temperatures likely to be realised in practice, to be completely impervious to furnace gases, and to be without action on the iron. Even if it met all these requirements there would still be the difficulty that, with one exception, so far as my investigations go, no iron alloy remains quite unchanged in volume after repeated heatings. Either there is growth or shrinkage. It may be very slight, but none the less it is there. I know of no glaze or enamel which would adhere under the above conditions, and I think there would be great difficulties in the way of making one, so that I have attempted a solution on different lines.

The root of the trouble is not the silicon, which by itself does not cause growth, but *free carbon*, which has no direct connection with it, merely acting as the channel for the gases penetrating to the silico-ferrite. It appeared, therefore, that the best chance of solving the difficulty was to find an alloy that would fulfil industrial requirements, and which not only contained no free carbon, but would not deposit this on repeated heatings. The white cast irons low in silicon, and containing not more than 3.5% of carbon, do not grow on repeated heating. On the contrary, they shrink to a slight extent. It would be desirable from the point of view of non-growth that they should not contain more than 0.3% of silicon. This would make them very costly materials, almost as expensive as cast steel. Moreover, owing to the pronounced crystalline structure of such castings, the crystals arranging themselves at right angles to the cooling surfaces of the mould, these irons would be almost certain to crack on heating. If the carbon is dropped below 2.5% the region of steel is entered and the material ceases to be cast iron. The white cast irons, therefore, containing mainly iron and carbon only, must be regarded as unsuitable alloys because they are too costly and too brittle.

The iron carbon alloy lowest in carbon examined

by me, which was in reality a cast mild steel, appears to have several points in its favour. It is a very ductile material, and hardly changes in volume on repeated heatings. I have been informed that a mild steel of this type has been successfully used for annealing ovens and has not grown appreciably. It has also been used with complete success for high-pressure steam valves and turbine casings, but owing to its high melting point it is a good deal more expensive than ordinary cast iron. Although this particular alloy was made from pure Swedish irons, there is no reason why English mild steels should not be used, even though they are higher in impurities. At high temperatures, however, these materials lose their mechanical strength, and they would be unsuitable for such purposes as grate bars. This difficulty could be met, at any rate to some extent, by increasing the carbon up to, if necessary, 1.5 or even 2%. This would give a more fusible, and therefore cheaper, alloy, and one which is much stiffer at a red heat. There is, I think, an opening for what may be called hard steels of this type.

Returning to the region of cast iron, it will be remembered that I found that manganese retards the rate of growth in all cases and diminishes it in most cases. So does phosphorus, but whereas this renders the cast iron brittle, manganese toughens it to an appreciable extent. Taking all the facts into consideration, it appeared that the influence of manganese should be more thoroughly investigated, and that alloys containing about 2.5% of carbon, 0.5 to 0.6% of silicon, and varying amounts of manganese, might be expected to furnish one of very small and perhaps negligible growth and of sufficient toughness. In the first series three alloys were cast containing respectively 0.51, 0.73 and 0.93% of manganese. They were white irons and very hard but tough. The ultimate stresses varied from 20 to 22 tons per square inch. These bars were heated for 150 four-hour heats at 850 to 900° C. After about 50 heats scale began to form, and this affected the accuracy of the measurements tending to produce high results, so that the growth figures appear somewhat larger than they really are. None of the bars cracked during the treatment. Each of them contracted slightly, but afterwards began to grow. The final results were as follows:—

No. 1.	Percentage Manganese.	Percentage Growth.
1	0.51	7.49
2	0.73	6.06
3	0.93	3.09

It will be observed that the growths are in the

* *

inverse order of the manganese contents. These results, while not constituting a solution of the problem, were distinctly promising, for they indicated that the manganese was the key to the situation, and that by increasing this still more an alloy of negligible growth would be obtained. Accordingly a fourth alloy was made, containing 1.64% of manganese, and tested in the same way. Its ultimate stress was 22.41 tons per square inch, and its mechanical properties were similar to those of the previous three alloys. It contracted very slightly but steadily for 75 heats. Afterwards the contraction diminished to a slight extent, but the alloy, even after 150 heats, was 0.13% smaller than its original size, so that under these conditions it may be claimed as a material that does not grow after repeated heatings. Moreover, it exhibited a valuable peculiarity which differentiates it from grey irons under the same treatment. The latter rapidly deteriorate in mechanical properties with repeated heating, whereas this alloy actually improved, its tenacity rising from 22.4 to 24.7 tons per square inch. From the practical standpoint this improvement is most important.

This alloy may be regarded as a manganiferous semi-cast iron, the presence of the manganese serving to prevent the separation of carbon in the free state, and at the same time toughening the material. The experiments have shown that in order to obtain an alloy whose growth on repeated heating is negligible, about 1.5% of manganese is needed when 2.5% of carbon is present. The melting point of such an alloy is about 1,346° C., a figure which is almost identical with that of a No. 1 hæmatite pig iron containing 4.2% total carbon. From a practical standpoint, there is no reason why the sulphur and phosphorus should be as low as 0.01% each. They could quite well be raised to 0.05% each, figures which would bring them within the range of English irons, and lower the melting point to very little above 1,300° C. Such an alloy, however, would probably run more thickly than a hæmatite No. 1 iron at the same temperature, and therefore for founding purposes the working temperatures would have to be higher. Chromium has the same beneficial effect as manganese, and its specific action is even more powerful.

It appears to me that an alloy of this type might be tried for annealing ovens, grate bars, rolls, furnace grids, high-pressure steam valves and turbine casings, in place of the present grey irons, whose growth is so annoying a characteristic. I think, also, it would be worth trying for ingot moulds in an iron foundry. If it is found to be too brittle and to crack on heating, then the carbon and the manganese can be lowered, the former to 1.75 or even 1.5% and the latter correspondingly. If the iron is not exposed to a temperature higher than that of the steam superheats in vogue, the carbon might with advantage be dropped to that of ordinary mild steel, and in that case the manganese could also be lowered to the ordinary figure. But where, as in the case of ingot moulds for iron, grate bars, and annealing ovens, the material

has to have considerable strength at high temperatures, this can best be secured by raising the carbon to the figure I have given and rendering the carbide stable by the addition of sufficient manganese.

Ingot moulds for large steel castings probably constitute the most difficult problem of all as regards growth. Usually these are made of an open grey hæmatite pig iron, and they seldom last more than 150 to 180 heats. In my paper read before the Iron and Steel Institute, May, 1911, I ventured to recommend a mild steel for this purpose. This recommendation was criticised on the ground that it had been tried and failed owing to a surface fusion between the mould and the casting. Nevertheless, it appears from an article in *Stahl und Eisen*,¹ that not only this, but other difficulties in connection with the use of steel have been overcome, and that several works in Germany habitually use steel and not cast iron moulds for steel castings. In the early days of experimentation, it was found that the moulds warped after a few heats. This difficulty has been solved by strengthening the sides of the mould with structural steel screwed longitudinally. It is stated that the most suitable material is either a Bessemer or an open hearth iron of substantial tenacity. The moulds should not be water-cooled but merely air-cooled. This has entirely got rid of the warping. The average life is 250 heats; single cases of 300 heats are not infrequent. Another advantage is that the melting of the base plates of cast iron moulds which is so unpleasant a feature of their use is entirely avoided. The ingots are sharp and clean. In the discussion it was mentioned that excellent results had been obtained with moulds containing from 0.30 to 0.35% of carbon. Two of these had stood 340 and 342 heats respectively. In another case it was reported that successful results had been obtained with moulds containing 0.25% of carbon, while in yet another a hard steel mould containing 0.75% of carbon was stated to have lasted 270 heats. From these results it would appear that there is a considerable variety of choice as regards the most advantageous composition.

With reference to first cost, there are several places in Germany where open hearth or Bessemer steel is cheaper than the highest grades of hæmatite pig iron, which costs about 70s. per ton. Further, a higher price can be obtained for used steel than for used cast iron moulds. Under these circumstances, therefore, it is not surprising that in Germany the tendency is to substitute cast iron by steel in making ingot moulds.

There will, however, be numerous cases in which, for one reason or another, it is necessary to use one of the ordinary grey irons on the market, and where all that can be hoped is to keep down the growth to a minimum figure. Speaking generally, I think there is no doubt that the most suitable irons of this type at present available are the cold blast pig irons. Whether they contain a different variety of graphite from that present in the hot blast irons has not yet been shown, but there is no doubt that on repeated heatings the cold blast irons grow less than the hot

¹ August 10th, 1911.

blast irons. Usually they contain less silicon, and this in itself is sufficient to account for the smaller growth. The subjoined analysis of a Staffordshire cylinder iron appears to me to be particularly suitable:—

Silicon ..	0.93 per cent.
Graphite..	2.50 ..

Combined carbon	0.50 per cent.
Phosphorus ..	0.45 ..
Sulphur ..	0.08 ..
Manganese ..	0.56 ..

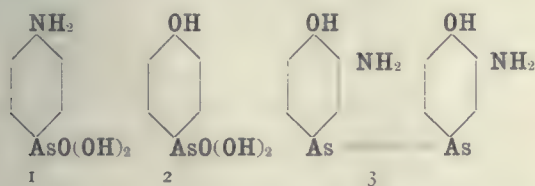
The ultimate growth of such an iron on repeated heating to 850° C. would probably not exceed 10 % and might be less.

THE ORGANIC COMPOUNDS OF ARSENIC AND ANTIMONY.

By ARTHUR CLAYTON, D.Sc. (Lond.), A.R.C.S.

ALTHOUGH organic compounds of arsenic and antimony have been known for many years, they have only recently been recognised to possess any great practical value. During the last four or five years, however, a considerable amount of attention has been given to these compounds, owing to their specific action in the treatment of diseases of protozoal origin, such as sleeping sickness, syphilis, etc. A powerful impulse was given to the investigation when it was found that the well-known compound obtained by heating together aniline and arsenic acid is really *p*-aminophenyl arsenic acid (Formula 1), the sodium salt of which is used in medicine under the name "atoxyl." This discovery led to numerous researches on the subject of aromatic arsenic compounds, with the result that many new and interesting substances have been prepared and their curative properties investigated.

It has been shown that, in general, aromatic amines and phenols having an unsubstituted *para*- or *ortho*-position react with arsenic acid, yielding aminophenylarsinic and hydroxyphenylarsinic acids; aniline and phenol, for example, furnish *p*-aminophenylarsinic and *p*-hydroxyphenylarsinic acids respectively (Formulæ 1 and 2).



Of the substances prepared in this way, the best known is still atoxyl, but several similar compounds have obtained a more or less extended use in medicine. All substances of this nature, however, have to be administered with caution, or harmful by-effects may be produced, which may even culminate in blindness. The most important application of these compounds is in the treatment of sleeping sickness, which is caused by a protozoal parasite, the *Trypanosoma gambiense*, but they are also employed in cases of syphilis. For the latter purpose, however, it is probable that the arsenic acids are not so useful as compounds of mercury.

Of the many compounds containing pentavalent arsenic which have been brought to light, the only

ones of therapeutic importance are atoxyl, arsacetin (the acetyl derivative of atoxyl), and the corresponding compounds of *o*-toluidine.

By the reduction of the arsenic acids, many compounds have been prepared in which the arsenic is present in the trivalent condition, and in general these have been found to be far more active than the arsenic acids. Noteworthy among the substances so obtained is a compound which has attained great notoriety as a specific in the treatment of syphilis; this preparation is dihydroxy-diamino-arsenobenzene (Formula 3), better known as "salvarsan," or "606," and is extremely efficient in combating the disease for which it is employed. The substance is prepared from *p*-hydroxyphenylarsinic acid (Formula 2), which is nitrated with a mixture of nitric and sulphuric acids, the entrant nitro-group taking up an *ortho*-position with respect to the hydroxyl group. This nitro-compound, on reduction, yields the final product. Unfortunately even this compound now appears to produce harmful by-effects; indeed, there is as yet no compound known which is fatal to the parasitic protozoa without being also more or less toxic to their host.

It is evident that in prosecuting researches having for their object the preparation of compounds of arsenic of therapeutic value, it is of the greatest importance to obtain as complete an insight as possible into the manner in which arsenic compounds affect the protozoa causing the disease, and this question has naturally been the subject of much discussion. It is found that atoxyl does not kill *Trypanosoma gambiense* in blood serum *in vitro*, although in the body it has a powerful trypanocidal action, even when present in very high states of dilution. This remarkable fact may be explained by assuming that atoxyl is decomposed in the body with the liberation of arsenious oxide, and this assumption is strengthened by the fact that the latter compound is an active parasiticide *in vitro*. An argument against this view, however, is presented by the facts that no arsenic acid is excreted, and that some preparations have been obtained which are many times as active as inorganic arsenic. Another, and perhaps more probable, explanation is that the body changes the atoxyl into a more toxic compound, which has a very powerful trypanocidal action. That some such powerful compound is so produced

is rendered highly probable by the fact that most of the atoxyl is excreted unchanged, so that presumably only a small proportion is used in killing the protozoa. The hypothesis receives further support from the observation that the trypanocidal action of atoxyl is proportional to its toxic action on the host, thus indicating that the parasitocidal action is connected with, and perhaps dependent on, the changes wrought in the tissue of the host.

The marked success which has attended the use of organic compounds of arsenic in the treatment of diseases of protozoal origin has led to the examination of the action of antimony compounds in the same connection. It was found that antimony is even more powerfully trypanocidal than arsenic, but it suffers from the disadvantage that its inorganic

compounds are strongly irritant, whilst aromatic compounds corresponding to those of arsenic are only being obtained with difficulty by the most persistent research. From the progress which is being made, however, there can be but little doubt that further developments in the chemistry of organic compounds of antimony will soon make their appearance, and according to present indications, new compounds of therapeutic value should be obtained. Whether or no these compounds will prove to be of greater value than those of arsenic it is, as yet, impossible to say. The physiological action of drugs varies so enormously with the slightest changes of chemical structure, that only by appeal to actual experiment can the therapeutic value of any substance be definitely ascertained.

CALORIFIC POWER STANDARDS FOR TOWN GAS.

By J. H. COSTE, F.I.C.

THE Metropolitan Gas Committee, 1904, (Lord Rayleigh's Committee) recognised the growing use of gas for heating and other purposes which were not directly connected with illuminating power, and in consequence recommended that the gas supplied by the Metropolitan gas companies in the portions of their respective areas within the City and County of London should be tested as to its calorific power. It was not felt, however, that the time for fixing a standard was then ripe, and in 1905 this recommendation in favour of informational testing was embodied in a clause of the London Gas Act. In other subsequent Acts affecting suburban and other companies, similar clauses, allowing official testings for information, but not fixing any standards, were introduced. The implied intention is obviously that in due course an equitable standard may be fixed. Some, but not all, of the local authorities concerned have availed themselves of the opportunity thus afforded of collecting useful information. In three recent Acts standards of calorific power have been inserted, in each case by agreement between the promoters and the local authority.

Gas is sold in this country by the cubic foot ($X10^6$), as the most obvious and convenient British standard of volume, and gas meters, both "wet" and "dry," of reasonable accuracy, are constructed for use by consumers. The Sale of Gas Acts, 1859—1860, which provide for the testing of all meters used in this connection, allow an error of 2% in favour of the seller, or 3% in favour of the consumer. The latter party is protected as to price of gas, and an incentive to economy of working is given to the companies by the device known as the "sliding scale," first suggested by the late Sir George Livesey in 1874, and soon afterwards incorporated in an Act of Parliament (Commercial Gas, 1876).

A standard price (per 1,000 cu. ft.) and dividend are fixed for the undertaking, and for each penny decrease of the price charged to consumers a certain

fraction of a per cent. may be added to the dividend, and on the other hand the dividend is decreased in the same manner if the price of gas is increased. Provided the standards are judiciously fixed, the arrangement is to the mutual advantage of the parties.

In addition to regulating the unit of sale and the price of gas Parliament has required since 1860 in London,¹ and 1871 in the provinces,² that gas shall be of a certain standard of quality. Gas was used for many years almost entirely for yielding light by the incandescence of particles of carbon or carbonaceous matter liberated in, and heated by, the flame produced by its combustion. It was then reasonable that the illuminating power should be the sole positive requirement as to quality. The advent of the gas engine, the gas cooker, gas fires, and many similar heating appliances has opened up a new field for gas enterprise, and concurrently there has been the great development of gas lighting by utilising the incandescence in a gas flame of bodies of greater emissive power than carbon—the well-known incandescent "mantles." The need for a standard of calorific power rather than of direct illuminating power is more and more felt, and as has been already stated in three cases the permissive testing clauses have been made the basis of standards. An examination of the forms of the respective standards which have been fixed will show the various points which have to be considered. The earliest standard, that of the Gas Light and Coke Co. (Act of 1909), is 125 calories *net* per cu. ft. with certain allowances for averaging small deficiencies over three days, etc., which reduce the working figure to 112.5 calories. The second standard, that of the Wandsworth, Wimbledon and Mitcham Amalgamation (Act of 1912), is 136 calories *gross*, with similar allowances down to

¹ Metropolitan Gas Act, 1860.

² Gas Works Clauses Act Amendment Act, 1871.

122 calories *gross*, and that of the South Suburban Co. (Act of 1912) is expressed in British thermal units, 540 B.Th.U. *gross* being the standard and 475 B.Th.U. the lower figure. It is almost generally agreed that the determination of gross calorific power is, on the whole, less liable in practice to serious error and is freer from experimental error than that of the net, and it appears to be felt strongly by British gas engineers that the British thermal unit is more suitable for use with the cubic foot than the calorie (see table).

So far as the figures of the standards are concerned it may be said that they are not at all unreasonably high, and that, considering the fact that calorific power appears to vary to one-half the extent that candle power does for the same gases, compliance should not be difficult. At the same time they fairly represent a quality of gas which can easily be obtained by the economical carbonisation of coal, or by admixture of such gas with moderately enriched water gas,¹ and which is suitable for most modern uses. Gas of this kind is not

distributing main, or as supplied to a testing place, will, in most cases, be made with a flow calorimeter—that is, one in which a constant stream of gas heats a constant stream of water. It is clear that when an instrument of the latter class is started some time will elapse before the heat has been so distributed throughout the instrument itself, that only a very small proportion of the total increment of heat is required to make good losses by radiation, etc. When this point is reached, as indicated by a steady difference of temperature between inlet and outlet water, it may be assumed in well constructed instruments that all the heat imparted to the system by the burning gas is communicated to the outflowing water and (in a much less degree) to the gaseous products of combustion. Practically all the water produced by combustion of hydrogen will be condensed, and its volume gives, by a simple calculation, the material for obtaining the amount of deduction to be made from the gross calorific power if it is desired to determine the net. It is useless to attempt either (1) to calculate the gross

COMPARISON OF STANDARDS OF CALORIFIC POWER.

	Gas Light and Coke Co.		Wandsworth and Putney Gas Light and Coke Co.		South Suburban Gas Co.	
	<i>Gross.</i>	<i>Net.</i>	<i>Gross.</i>	<i>Net.</i>	<i>Gross.</i>	<i>Net.</i>
Standard	(139 C.)	125 C.	136 C.	(122.4 C.)	(136.1 C.)	(122.5 C.)
Three-day figure ..	(551.6 B.Th.U.)	(496.0 B.Th.U.)	(539.6 B.Th.U.)	(485.7 B.Th.U.)	540 B.Th.U.	(486.1 B.Th.U.)
	(125 C.)	112.5 C.	122 C.	(109.8 C.)	(119.7 C.)	(107.7 C.)
One-day figure ..	(496.0 B.Th.U.)	(446.4 B.Th.U.)	(484.1 B.Th.U.)	(435.7 B.Th.U.)	475 B.Th.U.	(427.4 B.Th.U.)
	(118.3 C.)	106.5 C.	115 C.	(103.5 C.)	(112.6 C.)	(101.3 C.)
	(469.4 B.Th.U.)	(422.6 B.Th.U.)	(456.3 B.Th.U.)	(410.7 B.Th.U.)	447 B.Th.U.	(402.0 B.Th.U.)

Figures not in brackets are as referred to in Statute.

Figures in brackets are equivalent to the Statutory figures—gross or net.

1 Calorie = 3.968 B.Th.U. (Note.—The K. G. calorie is used in all cases.)

pre-eminently suited for burning in flat flame burners, although it will give a useful illumination in suitable burners of this kind. The advantages accruing from any economies effected by the companies should be felt by the consumers in the application of the sliding scale.

It behoves all gas engineers and gas examiners to become acquainted, by actual testing, with the calorific power of the gas which they control, with a view to replacing equitably the old standard by the new as occasion may arise. In this connection a consideration of methods and appliances may well follow that of standards.

Since the calorie and the British thermal unit are both based on the amount of heat required to raise unit weight of water through one degree—the former is a kilo.-Centigrade and the latter a pound-Fahrenheit unit—it is in the interests of simplicity to employ a water-heating calorimeter. Here we still have a fairly wide choice. A careful worker can obtain good results with a still-water calorimeter with a holder in which a small sample of gas may be stored, and from which it can be burnt. Instruments of this kind are of use in works or for occasional testings, but the regular testings of gas as issued from the

calorific power before the outlet thermometer has reached a maximum, and is varying only as affected by slight fluctuations of gas or water supply, or (2) to determine the net calorific power before the whole of the passages traversed by the products of combustion are properly moistened. Before commencing testings the worker must be satisfied that he has an adequate water supply which can be delivered to his calorimeter at a temperature which does not fluctuate more than, say, $\frac{1}{10}^{\circ}$ during an experiment. What this temperature should be is a matter of opinion. The Gas Referees prefer the water to be drawn from the house main, which in winter is at a much lower temperature than the testing room. The Paris authorities prescribe water about as much lower than the room temperature as the outlet water from the calorimeter is likely to be above it. The American Gas Association Committee on calorimetry prefer the water to be at the temperature of the room. On the whole, I believe the last plan to be the best, because the most definite, but there are small sources of error affecting each arrangement. The steadiness of water flow is usually maintained by a weir arrangement, which insures a constant, but preferably also, an adjustable head. The steady flow of gas can only be obtained by

¹ I.e., carburetted water gas—a mixture of water gas and oil gas.

the use of some form of pressure regulator, either a "balance" water governor, or a leather diaphragm governor. Neither of these will give a perfectly steady flow of gas, but the approximation is sufficient since several readings of the water outlet thermometer are taken, and the average will represent the mean temperature during the period of a testing. The gas must be measured, and for this purpose a wet meter, *which is from time to time verified by means of a standard holder*, must be used. It is not sufficient to rely on the line scratched on the glass side window, which roughly indicates the level of water required for the meter to deliver its nominal capacity of gas. The divisions on the meter dial indicating fractions ($\frac{1}{100}$) of a revolution usually very closely agree with the supposed fraction of the volume delivered during a revolution, but it is by far the best to burn during a test an amount of gas corresponding to an exact number of revolutions of the meter. The water in the meter should not only be at the temperature of the room, but it should be saturated with the gas to be tested. As new water is likely to take out soluble constituents from the gas, that already in the meter should be kept if it is necessary to empty it for removal or repair.

There are many patterns of flow calorimeters, but it is sufficient to consider the merits of the best known. All persons undertaking tests under statute will probably use Boys' calorimeter.¹ Many unofficial workers will prefer Junkers'. I have shown that the indications of these instruments are practically identical, and that it is principally a matter of taste which is used.² Junkers' is more convenient for work in which a determination of the *net* calorific value is desired. Both are very durable if well used. The time required to warm them to a stationary temperature does not differ greatly. It is important that the thermometers used are good, well paired, and finely divided. They must be read with lenses, or considerable errors of parallax may occur. The relative rates of flow of gas and water should be so adjusted that a convenient rise of temperature is obtained. The Gas Referees allow about 20°C. I think 10° would perhaps be better, but it is rather a matter of taste. In Junkers' instrument a graduated tap regulates the flow of water. The overflow cistern of Boys' can be hung on one or other of a series of nails knocked in a vertical board hung on the wall, or a small diaphragm, which is supplied to fit in the water connection, may be reamed out to increase the flow.

It is at times necessary greatly to increase the head of water, or to blow through the water inlet tube when the instrument is full, in order to remove air bubbles which may obstruct the free flow of water. An occasional washing with very dilute hydrochloric acid will remove any deposit of calcium carbonate.

It is usually sufficient to measure the water rather than to weigh it, and to assume that its

specific heat is constant, although small errors are thereby introduced.

It is in all cases necessary to see that the gas is perfectly burnt. The burner flame in Junkers' instrument should be adjusted to have a slight luminosity at the tip, and the consumption of gas should be so regulated that there is no fear of the flame being cooled by touching the upper part of the calorimeter, or of a greater amount of air being required than its own aeromotive power will supply. The luminous flames of Boys' calorimeter should burn clearly, without touching one another, and should not be so large as to touch the sides of the chimney. Very rich gases can be burnt satisfactorily with the air supply allowed by the normal adjustment of this calorimeter if the consumption of gas is suitably reduced as shown by the size of the flames.

In both the actual operations of testing and the fixing of standards a certain amount of scientific acumen and experience combined with common sense are required.

Nomenclature of Alloys.—As a result of a suggestion contained in a Paper on "The Nomenclature of Alloys," read by Dr. W. Rosenhain, B.A., before the Institute of Metals in January last, a committee consisting of representatives of the Institute of Metals and Allied Societies has been appointed under the name of the Nomenclature Committee, and will shortly hold its first meeting. The following representatives on this committee have been appointed:—

Institute of Metals: Dr. W. Rosenhain, B.A. (Chairman of Committee); G. A. Boeddicker, Esq.; Professor H. C. H. Carpenter, M.A., Ph.D.; Dr. Cecil H. Desch; Engineer Rear-Admiral G. G. Goodwin, R.N.; G. Hughes, Esq.; Sir Gerard Muntz, Bart.; A. E. Seaton, Esq., and Professor T. Turner, M.Sc. *Institution of Electrical Engineers*: W. Murray Morrison, Esq. *Institution of Mechanical Engineers*: G. Hughes, Esq. *Institution of Naval Architects*: Sir W. E. Smith, C.B. *Institution of Engineers and Shipbuilders in Scotland*: Alexander Cleghorn, Esq. *North-East Coast Institution of Engineers and Shipbuilders*: The Hon. Sir C. A. Parsons, K.C.B. *Society of Chemical Industry*: Professor W. R. Hodgkinson, Ph.D.

Physical Society.—The eighth annual exhibition of electrical, optical, and other physical apparatus was held at the Imperial College of Science and Technology, South Kensington, on December 17th last. A number of firms exhibited apparatus: R. and J. Beck, Ltd., exhibited a complete microscopical outfit for the examination of metal specimens and a $\frac{1}{4}$ h.p. grinding and polishing machine. The Cambridge Scientific Instrument Co., Ltd., exhibited The Féry Bomb Calorimeter, which gives direct reading in calories. C. F. Casella & Co., Ltd., exhibited rain gauges, a fog signal recorder, and surveying instruments. J. J. Dallmeyer, Ltd., had a satisfactory exhibit of lenses including an 11 in. diameter, 45 in. focal length lens working at F/4.2. Exhibits of Newton's F/1 lenses for cinematograph work and telephoto lenses working at F/4.5 were noticed. The Forster Instrument Co. exhibited a Recalescence outfit giving direct readings of the recalescence point in any sample of steel. A. Gallenkamp & Co. exhibited handy forms of electrical furnaces working at 1,100°C.

¹ This instrument and the method of using it are described in the notification of the Metropolitan Gas Referees.

² *Jour. Soc. Chem. Ind.*, 1909.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

THE ACTION OF LIME IN THE FLINTSHIRE PROCESS OF LEAD SMELTING.

By C. O. BANNISTER, A.R.S.M., and A. V. ATLEY.

ALTHOUGH the reactions which take place during the roasting stage and the reaction stage of the Flintshire Lead Smelting process have received considerable attention and are fairly well understood, the exact action of the lime during the "setting up" stage of the process has remained doubtful.

In this process, high grade galena is first roasted on the bed of a reverberatory furnace, then the temperature is raised and the charge melted down, part of the lead being reduced; slaked lime is then added to the unreduced portion which is spread over the bed of the furnace, recalcined and resmelted. This process of "setting up" with lime is often repeated a second time.

Various theories have been suggested to explain the action of the lime in this setting up stage, the most important being:—

(a) That its action is mechanical, cooling the charge and keeping it in a porous state, so that the various compounds present may interact more completely.

(b) That its action is chemical, forming compounds which react with lead sulphide, etc., giving a larger extraction of metal than would be possible without its use.

In this connection Hofman states that in this process:—"To counteract the melting of the charge, slaked lime is added which acts mechanically by rendering the charge less fusible and spongy. It also assists the process chemically by liberating lead and by decomposing the sulphide." Collins gives it as his opinion that while the principal function of the lime is undoubtedly mechanical it may possibly assist in liberating lead oxide from the silicate formed during the first melting down, although the temperature at which this reaction begins is in all probability above that which prevails at the second calcination stage. It is, however, to Percy that we have to turn for the most valuable information on this question, as he deals fully with the problem. He states that the lime is added in the state of hydrate and tends to thicken the molten mass, partly by the cooling effect consequent on the evaporation of its water and partly by its intermixture as an infusible ingredient. In reply to the query as to whether the action of the lime may be chemical as well as mechanical, Percy states that it certainly exerts no sensible reducing action on the sulphide of lead, but suggests in guarded and qualified language that it may serve to displace protoxide of lead from its combination with sulphuric acid and so facilitate the reduction of the lead of the sulphate of lead, as the reduction of the sulphide

of lead is more readily effected by free than by combined oxide. Percy also places on record Mr. Dick's observations that immediately after the lime is thrown into the furnace, preparatory to the first setting up, the mass with which it intermingles appears, as it were, to burn like tinder, beginning at one part and quickly extending thence over the whole surface. The glow that is noticed during the

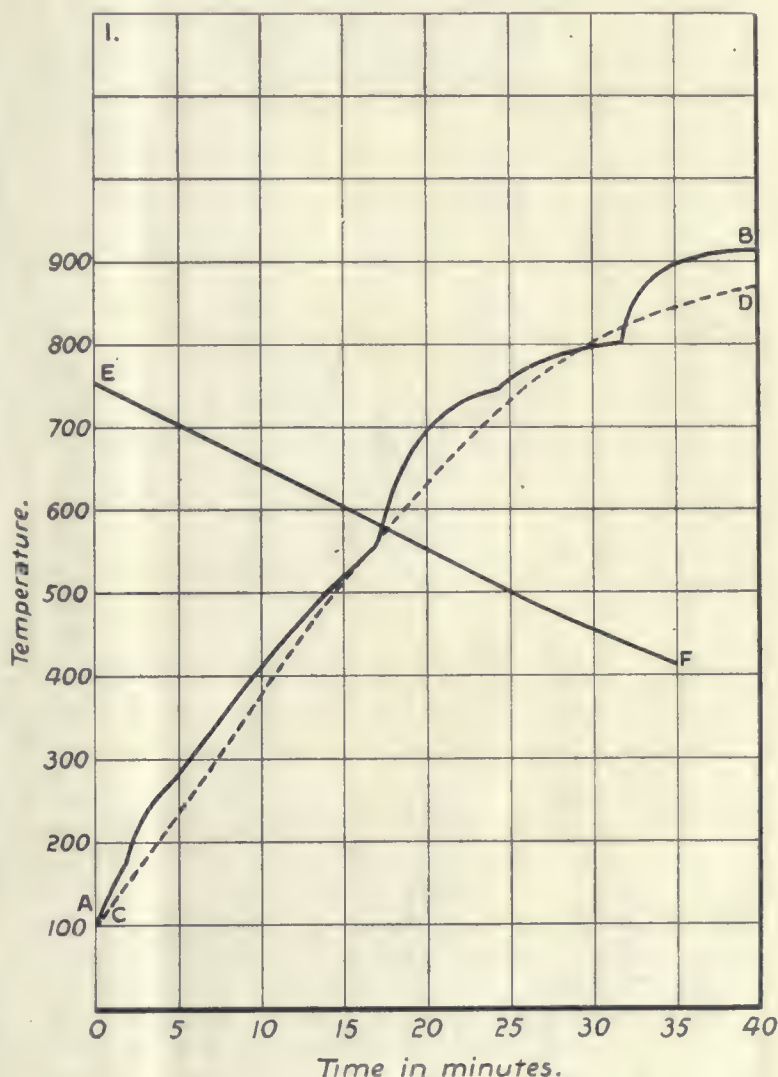


FIG. 1.

first setting up with lime is evidently of considerable importance, and a similar phenomenon was noted by W. M. Hutchings during experimental work connected with the Huntington and Heberlein process of roasting lead ores. He says, "if two scorifiers are charged, one with finely powdered lead sulphide ore alone and the other with the ore mixed with lime and placed side by side just within a muffle, at low redness the charge containing lime

will glow before the simple ore charge shows any sign of action; the charge containing lime rapidly ignites all over like so much tinder and heats up considerably above the surrounding temperature, at the same time increasing considerably in bulk. This lasts for some time during which very little sulphur dioxide is evolved. After the violent glowing is over, the charge continues to calcine slowly, giving off sulphur dioxide, but is still far more active than its neighbour. He found the roasted charge

with the compounds, the effects of which were to be examined, were placed in roasting dishes inside a muffle, and just under the surface was put a thermo-couple junction which was connected through a cold junction and resistance box to a mirror galvanometer. The muffle was then gradually heated by gas and the temperature readings taken every half minute.

Commencing with a sample of fairly pure galena mixed with 20 % of lime it was found on heating that at a low temperature sulphur flames covered the surface of the charge, and as the temperature reached a dull red heat, a surface reaction was noticed at one part of the charge. This gave a distinct glow which slowly covered the whole surface. After this reaction was finished, the whole mass became comparatively dull, and on continuing to raise the temperature to a red heat an exactly similar reaction or glow again occurred. Fig. 1, curve AB, shows the result of this experiment, curve CD showing the rate of heating the muffle.

This curve shows that between 180° and 280° C. a small evolution of heat is recorded, due to the burning of the sulphur, then up to 560° the temperature rises steadily. At 560°, however, a considerable evolution of heat takes place, this corresponding to the first glow noticed. The rapid rise in temperature slacks off at 730°, and at 745° a second slight evolution of heat takes place without, however, any apparent brightening of the charge. At about 800° a considerable evolution of heat takes place, the temperature of the charge rising rapidly to over 900°; this is found to correspond to the second glow noticed during the roasting of the mixture.

Experiments showed that as a result of the glows noticed, the charge increased in weight 5.5 % after the first glow and 13.9 % after the second glow, and at the same time the percentage of free lime decreased from 18 % in the original mixture to 13 % after the first glow, and to 3 % after the second glow.

As a result of the careful examination of these and other results it was concluded that at a temperature of about 560° rapid oxidation of the galena commenced with the formation of lead sulphate, lead oxide, and calcium sulphate, that at about 745° a reaction occurred between the remaining lead sulphide and the lead oxide formed during the roast.

On similarly roasting a mixture of galena and slaked lime somewhat different results

were obtained, only one distinct glow was noticed in the roasting mass, and this did not occur until a much higher temperature was reached than in the case of the quick lime mixture. Fig. 2 shows the type of curve obtained in this experiment, curve AB showing the result of roasting a mixture of galena and 20 % slaked lime, and CD showing the result of heating slaked lime alone in the same muffle. The curve AB shows that no great evolution of heat takes place until a temperature of 725° is reached; at this temperature, however, the mass is seen to glow brightly; the reason that no glow has taken place at 550°, as in the case of the galena quick-lime mixture, is explained by examining the dotted line CD, for between 500° and 600° a considerable absorption of heat has taken

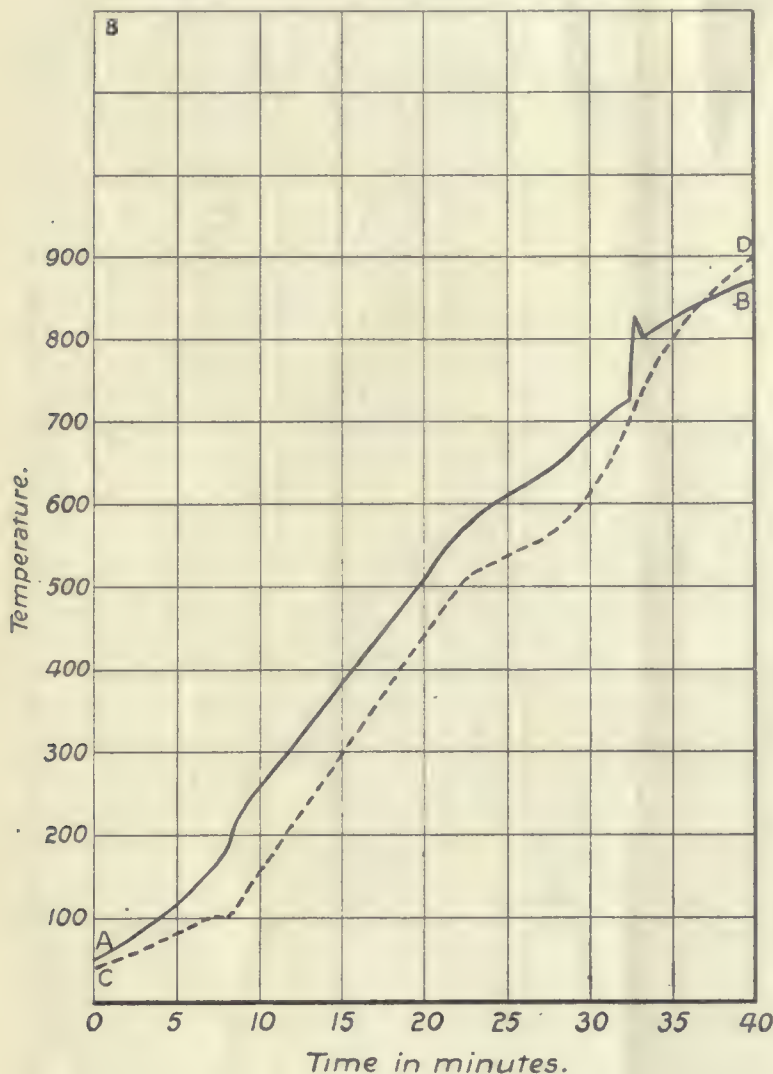


FIG. 2.

to contain no free lime, but large quantities of calcium sulphate.

Experimental work recently carried out at the Sir John Cass Technical Institute in an investigation of the theory of blast roasting of galena and communicated to the Institution of Mining and Metallurgy in February, 1912, has incidentally thrown considerable light on the problem considered in this article.

The experimental work was carried out with a view of examining the action of lime and other compounds on the roasting of galena and comprised the investigation of the thermal changes which take place during the roasts and the determination of the amount of sulphur dioxide evolved.

In the first series of experiments, the mixtures of galena

place in the dehydration of the lime, and it seems evident that the heat evolved in this range owing to the oxidation of the galena is used up in the dehydration of the lime. The sudden evolution of heat noted at about 725°, the temperature of the mass rising 100° in a quarter of a minute, is due to a combination of circumstances, including the rapid oxidation of the galena which has been somewhat delayed by the presence of the water, reactions between sulphide and sulphate of lead with oxidation of the metallic lead produced, and also the formation of a considerable amount of calcium sulphate. It will be noticed that the rise in temperature of the mass has been so great that it has been immediately followed by a cooling effect down to 800°, followed by a gradual rise of temperature.

Similar experiments carried out with mixtures of galena and silica or with galena alone showed that only a dull redness was produced at a temperature corresponding to that at which the first bright glow appeared when lime was present, and that the second glow was hardly perceptible, and temperature records taken showed only slight evolutions of heat at 560°, 730° and 810°, corresponding to the temperatures at which reactions are noticed in the galena lime roast.

The second series of experiments were conducted with a view of determining the rate of evolution of sulphur dioxide on gradually heating, in a current of air, galena mixtures similar to those used in the first series of experiments. The apparatus used consisted of an electric tube furnace, the temperature of which could be regulated with great nicety. Passing through the tube furnace was a porcelain tube in which was placed the sample under examination contained in a porcelain boat. Round the boat were placed the couple wires for recording the temperature, and at the opposite end of the tube to that occupied by the pyrometer wires were placed two wash-bottles containing water just coloured with a solution of phenol-phthalein. To the first wash-bottle was attached a burette containing a decinormal solution of sodium hydrate. To the exit tube of the second bottle was attached an aspirator to draw through the necessary air. After the boat containing the mixture and the thermo-couple wires had been placed in position, the aspirator was started and the furnace heated gradually. Whenever sulphur dioxide was drawn over, detected by the discoloration of the phenol-phthalein solution, the temperature was noted and the amount of sulphur dioxide determined by titration with the sodium hydrate solution.

In the experiments 2 gms. of the galena were taken, mixed with 0.5 gm. of lime, slaked lime or silica, giving a 20 % mixture in each case.

On roasting the galena and lime mixture in this manner, the results in the table following were obtained, thus showing that between the temperatures 500° and 830° small quantities of sulphur dioxide were evolved and that the total amount evolved was neutralised by 11.3 c.c. of the sodium hydrate solution.

On carrying out a similar experiment, using slaked lime, no trace of sulphur dioxide was evolved up to a temperature of 1,000° C.

In the case of the mixture containing 20% of silica, however, the results in the second table were obtained, thus showing that considerable quantities of sulphur dioxide were evolved during the roasting of this mixture, and that up to a temperature of 845°, 68.5 c.c. of the sodium hydrate solution were required to neutralise it.

On comparing the results of these three experiments it is seen that the slaked lime combines very effectively

with the sulphur dioxide evolved during the roast, that quick lime also acts in this manner, but not to such a marked degree, and that silica, by opening up the charge to the

Temperature.	Burette Reading.	Sodium Hydrate Solution used.
Degs. C.	C.C.	C.C.
500	2.4	2.4
640	3.3	0.9
730	5.9	2.6
810	8.1	2.2
820	9.3	1.2
830	11.3	2.0

action of the air, causes a large amount of sulphur dioxide to be given off.

As the result of a large number of analyses it has been shown that lime when present increases the relative proportion of lead oxide formed during the roast, and decreases the amount of lead sulphate formed.

The conclusions arrived at as a result of this work

Temperature.	Burette Reading.	Sodium Hydrate Solution used.
Degs. C.	C.C.	C.C.
525	2.4	2.4
550	5.3	2.9
575	10.0	4.7
600	13.5	3.5
620	17.5	4.0
640	21.1	3.6
650	24.9	3.8
660	28.0	3.1
680	29.8	1.8
690	31.6	1.6
710	33.2	1.6
730	35.4	2.2
740	39.1	3.7
750	41.7	2.6
760	45.5	3.8
770	46.9	1.4
775	48.5	1.6
785	50.8	2.3
790	52.0	1.2
800	54.6	2.6
805	58.0	3.4
810	61.6	3.6
820	63.5	1.9
830	65.5	2.0
845	68.5	3.0

are that the lime acts mechanically by keeping the charge open to the action of the air, by preventing the premature fusion of the mass, and also chemically by forming calcium sulphate, thus reducing the amount of lead sulphate formed and thus enabling a more complete reduction of the lead to take place by the interaction of the sulphide and oxide.

The Biochemical Journal, which has now become the property and the official organ of the Biochemical Society, has recently been taken over by The Cambridge University Press. The *Journal* will be issued from six to eight times a year, and will be under the editorship of Prof. W. M. Bayliss and Dr. A. Harden, F.R.S.

THE INFLUENCE OF OXYGEN ON COPPER AND ITS ALLOYS.

By J. A. PICKARD, B.Sc., A.R.C.S.

THE important influence of oxygen on the properties of copper has been recognised for many years, though conflicting statements have appeared as to the amount of oxygen which may be contained by commercial copper without injuring its usefulness.

In the ordinary process of purification a bath of metal freed from all but small amounts of impurities is obtained which contains a large amount (2 to 3%) of oxygen disseminated throughout the metal, and this oxygen is removed by the process of poling. The process consists in thrusting green wood below the surface of the molten metal, which is covered with anthracite, when the gases given off rise through and agitate the metal, reducing the oxide in their passage and also bringing the metal into more intimate contact with the anthracite. It is well known that the process may be carried too far, producing overpoled copper, which is brittle and inferior to tough pitch copper. This inferiority was at first attributed to the presence of a small amount of carbon, a theory which was easily disproved by analysis. It is now recognised as being due to the too complete removal of oxygen. Opinion is divided as to the exact mode of operation of the small amount of residual oxygen, but there is no doubt that the quality of commercial copper is improved by its presence in small amount.

The behaviour of copper-oxygen alloys—or rather copper-cuprous oxide alloys—has been studied by a good many workers, particularly by Hampe, Heyn, and Giraud. The facts established are briefly that the presence of cuprous oxide lowers the melting point of copper in accordance with Raoult's law of molecular depression of the freezing point until 3.45 % of cuprous oxide is present, when a eutectic is formed solidifying 19 degrees below the freezing point of pure copper. With higher percentages the melting point rises again and cuprous oxide separates in small globules mixed with the eutectic, though under certain conditions of cooling Cu_2O , Cu, and eutectic may be present. This is due to supercooling—cuprous oxide separating until after the eutectic composition has been reached, leaving the liquid richer than the eutectic in Cu. After a short time this excess of copper separates out with rise of temperature and the remainder of the alloy solidifies at the eutectic temperature. When other elements are present the behaviour is less simple and has not been so thoroughly worked out.

Copper which comes into contact when in use with reducing gases at high temperatures frequently becomes brittle and deteriorates. It is then said to have been "gassed." This deterioration is due to the removal of oxygen, though the effects of its removal on the structure of the copper are different from those produced by the removal of oxygen in overpoling. The exact method by which the removal of oxygen produces brittleness in finished copper has been the subject of a great deal of discussion, and is not settled definitely yet. Both ordinary copper containing small quantities of such impurities as As, Sb, Ag and Bi in addition to a little oxygen, and also copper containing only oxygen as impurity, when heated in hydrogen permanently expand and become brittle. With about 1.8 % of arsenic the brittleness is so great that the copper so treated is actually cracked and fractured. When broken

the fracture is intercrystalline, not passing through the crystals. This brittleness is not due to absorption of hydrogen, for it is produced equally well by reduction in carbon monoxide. It is true that carbon monoxide is soluble to some extent in molten copper, but as it causes trouble in castings by coming out again in solidification it is fair to suppose that absorption of CO is not the cause; moreover, it has been found that pure electrolytic copper, even when cast if free from contamination with oxygen, does not give rise to brittleness when similarly treated. It is obvious then that the cause of weakness must be sought in the oxygen-containing constituent of the metal, which solidifies last, round the grains of pure copper. Two possible explanations have been put forward. Bengough and Hill suppose that the break-up is due to the sudden evolution and subsequent expansion of gases produced by the reduction of the oxides—carbon dioxide and steam. It is difficult to understand how this can be the case, as in the chemical reactions which may take place ($\text{Cu}_2\text{O} + \text{H}_2 = 2 \text{Cu} + \text{H}_2\text{O}$; $\text{Cu}_2\text{O} + \text{CO} = 2 \text{Cu} + \text{CO}_2$; $\text{As}_2\text{O}_3 + 3\text{H}_2 = 2\text{As} + 3 \text{H}_2\text{O}$; $\text{As}_2\text{O}_3 + 3\text{CO} = 2\text{As} + 3\text{CO}_2$) the volume of gas resulting is in no case greater than that present before the reaction if the temperature remains constant; and as none of these reactions is of the nature of an explosion it is improbable that any considerable proportion of the reaction products would ever be much above the temperature of the surrounding mass. The other explanation, favoured by Huntington, Archbutt, and others, is that the chemical reactions taking place between the crystals of copper produce a lack of coherence, and consequently intercrystalline weakness. This explains the production of a more open structure in the metal, but will not account for any considerable expansion, as the volume of the copper produced is less than that of the reduced cuprous oxide.

The mechanism of the change producing brittleness in overpoled copper cannot be the same as in the above case, for the oxygen is removed when the metal is still liquid and has no crystalline structure. The two main theories are that it is due either (1) to absorption of gases which come out of solution again on solidification, or (2) to the reduction of some of the impurities present as oxides or salts to the metallic state.

Hofman, Hayden and Hallowell have proved that molten copper absorbs H, CO, and SO_2 , and that the solubility increases with the temperature and decreases with the Cu_2O content. If, however, we accept the statement of Percy that pure electrolytic copper cannot be overpoled we must seek another explanation of overpoling effects. The common impurities in copper are As, Sb, Bi, Pb, and Ag, of which the first three are generally considered most important. So unsatisfactory is the state of our knowledge of this subject, however, that the chemical state of combination of these elements in copper is still a very controversial subject. Huntington supposes that arsenic is present as copper arsenite, Bengough and Hill as arsenious oxide, while Johnson and others affirm that Cu_2O is not reduced by arsenic, which is dissolved in the copper as Cu_3As . A somewhat similar difference of opinion prevails with regard to Sb, but there is some evidence that Bi is present as an easily fusible eutectic alloy with copper which is very brittle and solidifies round the grains of pure copper; the effect of oxygen being to break up this structure and cause the bismuth alloy to occur massive in the form of small globules. With the data at present available it would be premature to dogmatise on the matter.

PROFESSOR H. E. ARMSTRONG, LL.D., Ph.D., F.R.S.

By WILLIAM A. DAVIS, B.Sc., A.C.G.I.

At the close of the present session, when the work of the Chemical Department of the City and Guilds College will be transferred to the Imperial College, a laboratory will cease to exist which has exercised what, without exaggeration, may be termed an unique influence on the history of chemistry in this country. The present moment, therefore, is a suitable one briefly to review in this journal the life work of Professor H. E. Armstrong, from the point of view both of his purely scientific activity and the influence he has exercised on the development of education and industry of this generation.

At a banquet given to Professor Armstrong in 1911 by his old pupils and friends, which the *Times* described as "one of the most remarkable gatherings of engineers and chemists that has been held in recent years," and at which more than 250 friends and old students came together from all parts of the United Kingdom to testify their esteem and affection, the chairman, Professor W. J. Pope, of Cambridge, himself an old student, described Professor Armstrong as having "written his name on most of the great chemical achievements of the past thirty years; no living chemist," he added, "in this country, has exercised a more generally stimulating influence on the progress of chemical research."

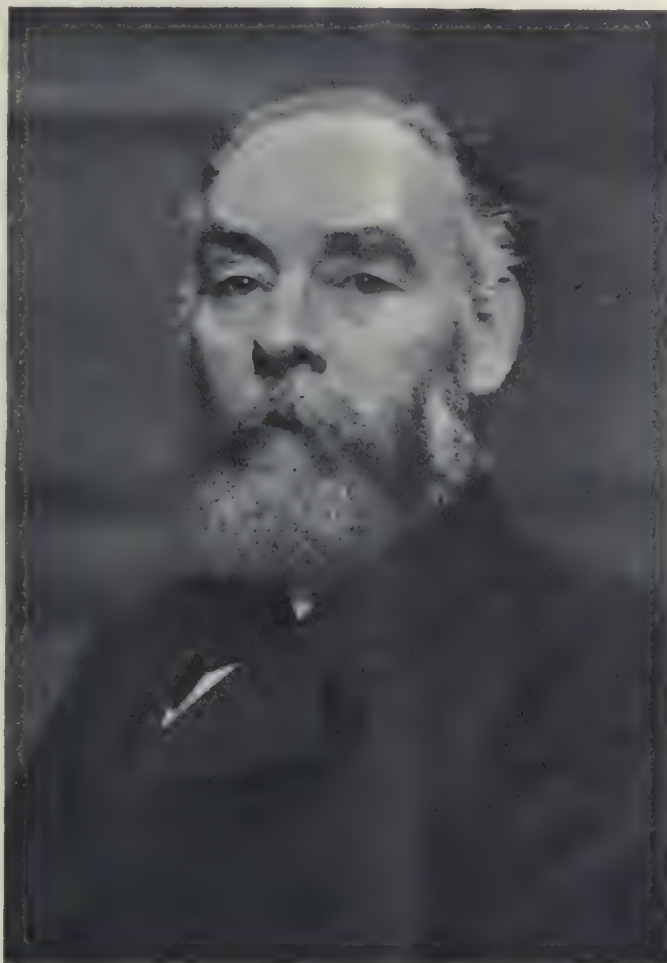
Professor Armstrong's first scientific paper was published jointly with the late Professor Sir E. Frankland in 1868, under the title "The Analysis of Potable Waters," and contained an account of the analytical processes which have since become classical. This work was commenced in 1866 at the

beginning of his second year as a student; he has himself told us how "Frankland made a pump, merely by sealing on a side-piece to a long length of narrow-bore glass tube, which served throughout the experiments. This was the first systematic use

of the Sprengel pump." Indirectly this work on the analysis of water led to a complete overhauling of our sources of water supply, and was the beginning of a great wave of sanitary reform. In the forty-four years that have elapsed since, Professor Armstrong's scientific activity may be estimated by the fact that he has published nearly eighty original scientific papers in his own name, a further 120 papers in collaboration with others, whilst more than 100 papers in addition have been published by students or members of his staff in their own names, but with the advantage of Professor Armstrong's criticism and advice, and often as the result of his direct inspiration.

On leaving Frankland, Professor Armstrong spent nearly three years with Kolbe at Leipzig, returning to London to act as assistant to Matthiessen at St. Bartholomew's Hospital, and shortly afterwards to be appointed professor of chemistry at the

London Institution. In 1878, the City and Guilds of London Institute was founded in consequence of the public outcry at the time that England was lacking in facilities for technical education, and in 1879 Professors Armstrong and Ayrton began the pioneer work at Finsbury, which has been reviewed in a previous article in *THE CHEMICAL WORLD* (November, 1912), and was the



Henry E. Armstrong

beginning of a wave of higher technical education in this country. From this nucleus grew the Central Institution at South Kensington, which later became the Central Technical College, and is now the Engineering College of the Imperial College of Science and Technology. Since 1885, Professor Armstrong has held the professorship of chemistry at this college, and the past twenty-seven years has been a period of truly amazing activity.

The early years at the "Central" were largely devoted to elucidating the questions of constitution

result of a series of researches, first threw doubt on the correctness of Kekulé's formula for camphor, suggested in 1873, which represented this molecule as derived from a six-carbon ring. In those days Kekulé's name carried universal sway, and his formula persisted until 1893, when it was finally deposed by the well-known formula of Bredt. A brilliant series of papers from the "Central" Laboratory, by Kipping, Pope, Lapworth, Forster and Lowry, followed. The study of the camphor-sulphonic acids in particular was of the very greatest



FIRST YEAR LABORATORY.

and isomerism of aromatic compounds, and a study of the laws of substitution in the benzene and naphthalene series; this work led to the "Centric" formula for benzene, which is now universally accepted, and, by a singular coincidence, was suggested independently at almost the same time by von Baeyer in Germany. In collaboration, mainly with Professor W. P. Wynne, more than fifty papers were published on naphthalene derivatives (1886—1897); how fundamental this work was, especially in relation to the modern industry of the coal-tar dyes, may best be gauged by a reference to the *Tabellarische Uebersicht der Naphthalin-derivate* of Reverdin and Fulda.

In quite early days Professor Armstrong, as a

importance, because it was by the use of these compounds that Professor Pope was enabled later to isolate for the first time optically-active compounds of nitrogen, sulphur and tin, thereby extending to these elements Van't Hoff and Le Bel's conception of asymmetry as the cause of optical activity of carbon compounds. The use of the camphor-sulphonic acids in chemistry, indeed, has had as great consequences as the introduction of phenylhydrazine as a reagent by Emil Fischer. Within the last month they have been applied with success by Professor Werner, of Zurich, in the isolation of optically active asymmetric compounds of cobalt.

The study of the stereo-isomeric, chloro- and bromo-camphors undertaken by T. M. Lowry, as a

student of Professor Armstrong, led to new conceptions as to the nature of sugars in solution and the cause of the change of optical rotation which was formerly known as *multirotation*, but is now generally, according to the suggestion of Lowry, termed more correctly *mutarotation*. This work had a logical consequence in the correlation of the two varieties of natural glucosides by E. F. Armstrong with the two stereoisomeric forms of glucose of which Lowry had first given proof, and an important series of papers on the nature of glucosides followed. From Lowry's work also first arose clear conceptions as to "dynamic isomerism" as an explanation of the phenomena

prophecy which was only realised in 1902 by Professor H. B. Baker's brilliant experiments. The inability of iron to rust in absence of a trace of acid, established by G. T. Moody, and the inhibition of chemical action by the removal of traces of moisture, are legitimate issue of this theory, and the same is true of the many brilliant investigations of the slow oxidation of hydrocarbons by Professor Bone and his colleagues, which have led to the reversal of the older theories of combustion and to important technical applications.

As is well known, Professor Armstrong has consistently been an opponent of the doctrine of electro-



THIRD YEAR LABORATORY.

formerly, and often still, loosely grouped under the vague and incorrect name of "tautomerism."

The work on glucosides was followed by an important series of papers on *enzyme action*, in which nineteen communications (1903 onwards) have been published, in collaboration with E. F. Armstrong and others, which are of the greatest significance in plant and animal physiology.

What in the future will probably be regarded as one of Professor Armstrong's principal achievements has been the development of his theory of the nature of chemical change. This formed the main subject of his presidential address to the Chemical Society in 1895, and of numerous papers before and since. Even as early as 1885 he ventured, armed with this theory, to prophesy that a mixture of *pure* hydrogen and oxygen would be found to be incombustible, a

lytic dissociation, the extreme views of which, in 1907, with characteristic vigour, he christened "ionomania." He maintains, with Faraday, that "attraction of aggregation," and not "the strange hypothesis that electrolytes are compounds gifted with suicidal mania," will be found to explain electrolytic phenomena, and in support of this view, and of the important part played by the *solvent*, has accumulated, since 1907, a very large amount of extremely accurate experimental material, published in a series of papers on "The Processes Operative in Solutions" and "The Origin of Osmotic Effects."

It is impossible here to do more than briefly allude to work in many other fields, such as the theory of the origin of colour and the nature of dyes, the action of acids on metals, plant metabolism and physiology, which, together with that already referred to, led the

Royal Society to confer on him the Davy Medal in 1911. Nor is it possible to do aught but mention the important services he has performed as Secretary of the Chemical Society for eighteen years, President of the Chemical Society (1893—1895), Vice-president of the Royal Society (1901—1902), and in connection with the initiation of the International Catalogue of Scientific Literature, the Mosely Education Commission, as a Governor of Christ's Hospital, on the Council of the Lawes Agricultural Trust, or as a member of the Consultative Committee on Education.

Professor Armstrong's services to education are now generally recognised, and the methods he initiated in teaching elementary science have been adopted, not only in this country, but copied throughout the world. Probably no single man has done so much by precept and example to replace the old bookish system of education, devised in the fifteenth century, by one more adapted to the wants of the present age. Elementary chemistry as taught in many of our schools now is not a mere collection of recipes, formulæ and equations, but has become a real means of training thought and action; the "atmosphere of research," which has been so striking a feature of the

"Central" laboratory, and the importance of which he emphasised even so far back as 1885, in a presidential address to the Chemical Section of the British Association, is now realised *in embryo* in many a school laboratory. The existence of this "atmosphere" in a supreme degree in the chemical department of the "Central" is shown by the history of its scientific achievements and the impress it has left on the industry of this country, more than one new branch of which, for example, that of artificial silk, has been largely built up by old students of the chemical department.

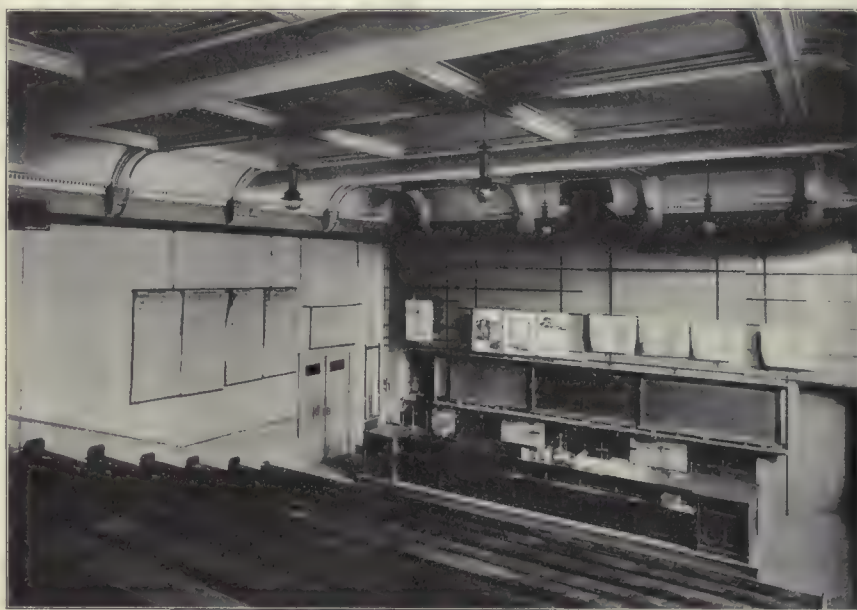
A few words may be added regarding the novel method of teaching chemistry which was adopted to meet the special requirements of students mostly destined to become engineers. The object aimed at in the first-year course was not, in the lectures, to cram the students with a large body of indigestible facts, nor, in the laboratory, to burden them with profitless test-tube manipulation in following an uninspiring analytical table, but to implant an idea

of the *principles* of the "art of experimental inquiry." One of his old students, now manager of an important electrical works, in attributing no little of his own success to Professor Armstrong's teaching, has said that the lesson he learned from this course, which has proved of the greatest possible value to him, was that "scientific knowledge was not the knowledge of what others had discovered but the knowledge of how to discover things oneself." "No method of teaching," he added, "could be better calculated to develop ability to think and act upon one's own initiative." The object aimed at in fact was to lay a broad foundation rather than too narrowly to specialise at an early age. Reference may here be made to Professor Armstrong's book on the "Teaching of Scientific Method" (Macmillan, 1903), which embodies most of his papers and addresses on this subject.

One special feature of the more purely chemical training at the "Central" must not escape mention, namely, the inclusion of crystallography as an integral part of the ordinary course; the first instructor was Professor (now Sir) H. A. Miers, and the inclusion of this subject has had as direct result some of the most striking achievements of modern chemistry, for

example, the discovery of optically active nitrogen and sulphur compounds, and the Pope-Barlow theory of correlating crystalline form and chemical structure, which bids fair to have as great influence on future chemistry as the doctrine of valency and the Van't Hoff-Le Bel hypothesis have exercised in the past.

In building up so important a "school" of modern chemists, Professor Armstrong's influence has been something more than that of a mere teacher of chemistry. As many of his old students, engineers as well as chemists, have acknowledged, his personality and method counted for much in the shaping of character. He took an active personal interest in each student's work and welfare, and his criticism and suggestions, both in the laboratory and at the College "Chemical Society," were invaluable for the formation of a healthy and active scepticism. Many of his old students can apply to themselves the words he has himself used in connection with Frankland: "It was of infinite import-



CHEMICAL LECTURE THEATRE.

ance to hear doubt cast upon current belief and authority called in question; the display of solid grounds for such disbelief was eminently inspiring." He has, himself the student of the "arch-heretic" Kolbe, given us as his favourite maxim in chemistry: "When in doubt, disbelieve until convinced of truth; and even then remain on guard."

His close personal relations with his students, which has been perhaps the chief factor of his success as a teacher, did not lapse when the student left

college. He has been ever ready to help them, not merely by advice on purely technical questions, but by more valuable assistance in forwarding their careers, and the recent statement by an old student who occupies one of the highest positions possible in the world of science: "How much many of us owe to him we shall probably never realise," will find an echo in the heart of innumerable others who are filling responsible positions throughout the world.

THE ALLOTROPY OF ANTIMONY: EXPLOSIVE ANTIMONY.

By T. MARTIN LOWRY, D.Sc.(LOND.), F.C.S.

Explosive Antimony.—The explosive variety of antimony was discovered in 1855 by Gore, who found that when a concentrated solution of antimony trichloride in hydrochloric acid is electrolysed, a metal is deposited which explodes with some violence when merely touched with a glass rod. The experiment is conveniently carried out by means of the apparatus shown in Fig. 1, in which the metal is dissolved from an enclosed anode and deposited from a well-stirred solution on the surface of a kathode of platinum wire. The rods obtained in this way (Fig. 2) are rinsed with hydrochloric acid, water, alcohol and ether, and are then ready for use.

When the rods are touched or scratched there is an explosion and white vapours of antimony trichloride are liberated. The explosion is accompanied by the liberation of an enormous amount of heat. A thermometer which had been silvered, then coppered, and finally coated with 20 gms. of explosive antimony, was found to rise in temperature from 17° to 310° C., when an explosion was started by scratching the metal. When the metal is exploded (by shaking it) in a thick-walled test-tube, containing a little ether and closed with a rubber stopper, so much heat is generated that the stopper is ejected with a loud report.

Solid Solution of Antimony Chloride in Antimony.

—The white fumes of antimony chloride which are expelled in the above experiments are an essential constituent of the explosive metal, save only that parallel phenomena are observed when the metal is deposited from concentrated solutions of the bromide and iodide. When cooled to -80° C. the metal

can be ground to a very fine powder without exploding. But no trace of antimony chloride can be extracted from the powder by soaking it in a solvent. The chloride is therefore, in all probability, present in solid solution in the metal, but is expelled when the "explosive" or α variety is converted into the "exploded" or β form of the metal. Precisely similar phenomena are known to occur in the cooling of steel, when the change from γ to β or α iron is accompanied by the expulsion of all the carbide from solid solution and gives rise

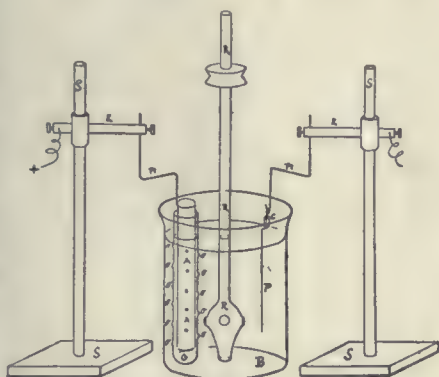


FIG. 1.

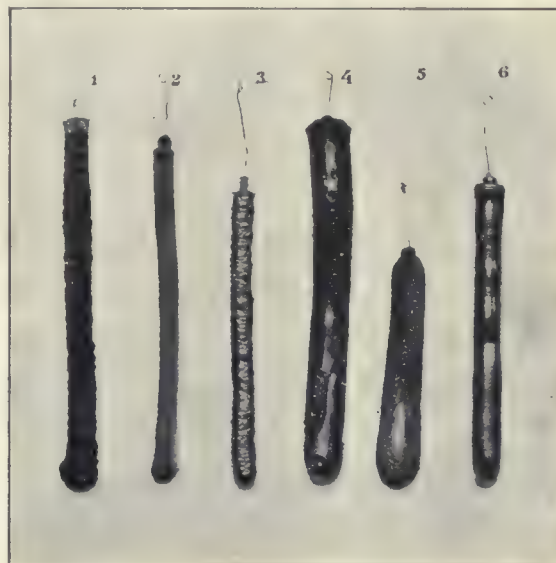


FIG. 2.

to a "recalcescence" of the metal; but in that case the rise of temperature is limited to something under 20° C., whilst the explosion of antimony raises its temperature by not less than 300° C.

Concentrations of Antimony Chloride.—Further evidence that the chloride is present in solid solution in the metal is afforded by the fact that there is a regular relationship between the proportion of chloride deposited with the metal and the concentration of the chloride in the solution. This relationship is shown in a curve in which the

concentration in the liquid is plotted horizontally and the concentration in the metal vertically. It is found that there is a sharp break in the curve when the concentration of the chloride in the electrolyte reaches 10%. The concentration in the metal, which had previously amounted only to $1\frac{1}{2}$ to 2% then rises abruptly to 4.5%, increasing thence progressively to 11.5%, when the concentration in the electrolyte is increased to 85%. It is only antimony containing these higher proportions of chloride that is explosive. It is clear from the original curve that, whilst non-explosive antimony may take up a little of the chloride, there is a much more marked tendency to form isomorphous mixtures in the case of the explosive form; it is therefore not unreasonable to conclude that the separation of the explosive variety is due to the influence of the chloride striving to secure the deposition of the metal in that allotropic form to which it has most resemblance. Such phenomena are extremely common in cases of "isodimorphism," and examples have already been quoted in describing the allotropy of sulphur in its relationships to selenium and tellurium.

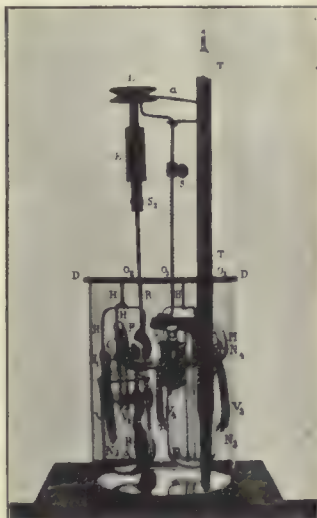


FIG. 3.

Thermo-chemical Measurements.—By exploding the antimony in a calorimeter the heat of the explosion of the metal may be measured. It amounts to 19.6 gm.-calories per gm. As the specific heat of antimony is about 0.05, the metal must be raised through about 390° of temperature during the explosion.

An ingenious method was adopted for testing the identity of "exploded" antimony with the ordinary form of the metal. The apparatus shown in Fig. 3 was arranged in a calorimeter; the tube on the right contained the powdered antimony and was exhausted; the tube on the left contained bromine dissolved in carbon disulphide. On opening the tap, the bromine solution was discharged on to the metal and converted into bromide, the heat of formation of which was measured by the calorimeter. The values found were—

For ordinary antimony 454.0 gm.-calories.

For exploded antimony 453.6 " " "

The latter sample of antimony, which had been exploded under ether, still contained its original proportion of antimony bromide; to allow for this an equal weight of antimony bromide was added to the bromine solution which was used to dissolve the ordinary metal. The almost perfect agreements between the two figures justifies the conclusion that "exploded" or β antimony is (in spite of the bromide or chloride which it retains) essentially identical with the ordinary form of the metal.

The author desires, in conclusion to place on record his indebtedness to Professor Ernst Cohen, of Utrecht (to whom all the experiments described above are due), for generously allowing him to reproduce the illustrations which accompany this description of his work.

NOTES OF MEETINGS.

INSTITUTE OF CHEMISTRY.

Mr. W. J. A. Butterfield, M.A., Assoc. Inst. C.E., F.I.C., will deliver a second Lecture on "Chemistry in Gasworks," during January, 1913, in the Chemical Lecture Theatre of University College. Professor Raphael Meldola, F.R.S., President, in the chair.

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CHEMICAL SOCIETY.

January 23rd, at 8.30 p.m. Ordinary Meeting.

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SOCIETY OF PUBLIC ANALYSTS.

January 1st, at 8 p.m. Ordinary Meeting.

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SOCIETY OF CHEMICAL INDUSTRY.

LONDON SECTION:—The next meeting of this section will be held on January 6th, 1913, when the following Papers will be read and discussed:—

- (1) "The Estimation of Moisture," by F. H. Campbell.
- (2) "The Determination of Water," by G. N. Huntly and J. H. Coste.

ROYAL SOCIETY OF ARTS.

On January 20th and 27th, two Lectures will be delivered by Professor Vivian B. Lewes on "Liquid Fuel," at 8 o'clock.

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ROYAL INSTITUTION.

January 17th, Professor J. J. Thomson, O.M., will deliver a Discourse on "Further Applications of the Method of Positive Rays."

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THE INSTITUTION OF CIVIL ENGINEERS.

January 14th, 21st, and 28th, at 8 p.m. Ordinary Meetings.

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THE INSTITUTION OF MECHANICAL ENGINEERS.

January 17th, at 8 p.m. General Meeting. Nominations for Annual Election of Officers.

MOLECULAR PHYSICS.

By J. A. CROWTHER, M.A. (Fellow of St. John's College, and Demonstrator in Physics in the Cavendish Laboratory, Cambridge.)

CHAPTER I.

INTRODUCTION.

THE history of the rise of molecular theory has often been written. From Dalton, who first gave to the conceptions of the early atomists a definite meaning and a real experimental basis, through Avogadro and his fertile hypothesis of the molecule, and so on to the kinetic theory of Clausius and Maxwell, the story is told in almost every text-book of Chemistry and Physics, and is familiar as household words to all their readers. Here for a time science seemed to pause in her progress. It seemed as if the memoirs of these brilliant mathematicians were to contain the last word in molecular theory.

If this had been so, the following pages would have been superfluous. In the last few years, however, new fields have been opened to the student of molecular phenomena; new methods of approach have been evolved so potent in character that subjects about which we had until then barely sufficient grounds for speculation are now laid open to direct experimental attack. The molecule has been raised from a conception only realisable experimentally in millions to the rank of a definite particle whose entry into our apparatus produces a definite and measurable effect. At the same time the accuracy, and what is still more important, the certainty, of our measurements of molecular magnitudes have been enormously increased. It seemed, therefore, neither undesirable nor devoid of interest to attempt to re-write the subject of molecular physics, not from the standpoint of the kinetic theory, by which it was approached historically, and which constituted for many years the sole line of attack, but rather in the light thrown upon these problems by the recent developments in what has come to be known as the "New Physics."

In order to fix our attention upon the problems to be dealt with, and to recall to our minds some clear ideas of the magnitudes with which we shall have to deal, it may be well to consider briefly the position to which we had been brought by the exponents of the kinetic theory.

The atom itself was a purely chemical conception. It took its rise in an attempt to explain the laws of chemical combination, and represents the smallest mass of an element which can take part in a chemical reaction. By its first exponents it was regarded as homogeneous and indivisible. This view is no longer held. We shall see later that we must conceive of the atom as something approaching a planetary system on an infinitesimal scale. A study of the phenomena of radioactivity has driven us to believe that in them we are dealing with a true decomposition of a true chemical atom; that the element radium is in fact a decomposition product of the

atom of uranium, and is itself in the course of transition into an atom of lead, with the emission during the process of several atoms of helium. This break up of an atom, however, is a process which we are permitted to watch, but not to control. So far we have not succeeded in either accelerating or retarding its progress in any way whatever.

In compounds the atoms of the different elements were supposed to be grouped together into similar particles or molecules, the ratio of the masses of the components being the same in each individual molecule as in the compound as a whole. It was soon found necessary to assume that even in the elements the atoms were usually connected into groups of two or more to form a larger particle, which, unless taking part in a chemical reaction, always moved and acted as a single system. This extension of the theory was due to Avogadro, and his additional hypothesis that the number of these molecules in a given volume of gas under similar conditions is independent of the nature of the gas was the first great generalisation in the physics of the molecule.

It was soon realised that these molecules were particles exceedingly small in size. Various attempts to determine the approximate diameter of the molecules all led to the result that it was not very much greater than 2×10^{-8} cms. Various illustrations have been employed to assist us to grasp the extreme minuteness of this quantity. If, for example, a drop of water were to be magnified to the size of the earth the molecules in it would be of the size of footballs. Or again, as a recent writer has suggested, we may say that the carbon atom in the printed page subtends at the reader's eye the same angle as would be subtended there by a man on the moon.

The number of molecules in any visible portion of matter is, of course, correspondingly large. According to the latest determinations the number of molecules in 1 cub. cm. of air under normal conditions (0° C. and 760 mm. pressure) is 2.7×10^{19} . It is almost hopeless to attempt to conceive this inconceivable swarm of particles. It may, perhaps, be of some assistance to point out that in the highest attainable vacua, when the pressure of the gas is not more than $\frac{1}{10000}$ mm. of mercury, the number of molecules present in every cubic millimetre of the space still exceeds 2,000,000,000.

In a solid body we must regard the molecules as relatively fixed. They are indeed in rapid vibration about their mean position, such vibration constituting the phenomenon which we know as heat. The fact that ancient gems and coins have come down to us through many ages still preserving their sharp outlines and their beautiful and clear-cut engraving shows that, in the absence of external forces, the defection of a molecule in a solid from its

original station must be of exceedingly rare occurrence.

In liquids, however, we must regard the molecules as free to move. A liquid has no definite shape of its own, and two liquids if left quite undisturbed will gradually diffuse through each other with a velocity which is in general small but quite measurable. The different molecules possess sufficient energy to escape from the attraction of neighbouring systems, but move only a very short distance through the thickly-crowded space before becoming entangled in other clusters.

Gases differ from liquids in the fact that the space occupied by a given number of molecules is very much greater; and a molecule therefore travels much further before coming into collision with other molecules. Thus a gramme of water substance when transformed into steam occupies 1,600 times the volume which it had in the liquid state. The molecules are therefore $\sqrt[3]{1,600}$ or, say, 12 times as far apart in the gas as in the liquid. The actual volume of the molecules themselves is thus only a very small fraction of the volume filled by the gas, the molecules occupying the space between their boundaries not by filling it with their bulk, but by moving about in it in all directions with considerable velocities. The tendency of a gas to spread through the whole of the space accessible to it thus represents the tendency of each molecule to proceed on its path in a straight line when not opposed by any obstacle, while the pressure on the boundaries of the gaseous space is due to the exceedingly rapid series of impacts made on them by the innumerable swarm of molecules in motion.

The velocity with which the molecules in a gas are moving can easily be calculated when the pressure and density are known. The mean velocity of a molecule of oxygen at the freezing point of water is about 425 metres per second, or about 1,000 miles per hour. It is, therefore, somewhat greater than the velocity of sound through air under the same conditions (331 metres per second). In addition to collisions upon the boundaries each molecule collides from time to time with other molecules of the gas, the number of collisions made by a single molecule under ordinary conditions of temperature and pressure being about 6,000,000,000 every second.

The distance travelled by the particle between two collisions is known as its free path. Its actual value between any two collisions depends, of course, upon chance. Its mean value can, however, be calculated from the viscosity of the gas. For air under ordinary conditions it is about 7.6×10^{-6} cms., or roughly $\frac{1}{1000000}$ of an inch.

This mean free path, although a giant among molecular magnitudes, is still rather smaller than the smallest distance we may ever hope to perceive. Abbe has shown that two objects would have to be separated by rather more than twice this distance before they could be resolved by the best possible microscope working under the best conditions.

The mass of each molecule is, of course, exceedingly minute; according to the recent determina-

tions of Rutherford, which we shall describe later, the mass of a hydrogen atom is 1.61×10^{-24} gms., a number so minute that it can hardly be said to convey to the mind any impression at all. This number, it will be seen, represents the value in grammes of the chemical unit of atomic weight; the mass in grammes of any atom or molecule can thus be calculated from a table of atomic weights by merely multiplying the chemical atomic or molecular weight by this factor. Small as is this quantity we shall see that its value is known with certainty to within a very few per cent.

Of the quantities with which we have been dealing, the kinetic theory gave accurately the velocity of the molecule and the mean free path. It threw only a dim and somewhat uncertain light upon the number and mass of the individual molecules. As to the nature of the molecule it can hardly be said to have given any information at all. It is at once the triumph and the failure of the statistical methods employed in the kinetic theory, that given a sufficiently large number of molecules, their exact number, size, mass and properties become for many purposes matters of indifference. Thus many of the properties of gases were successfully deduced, in the first place, on the assumption that the molecule was a hard sphere, an assumption which in the case, say, of a molecule like that of oxygen built up of two atoms is almost certainly incorrect. It will be seen then how little light can be thrown upon the individual molecule by investigations of this nature.

As the molecule itself lay far beyond the limits of vision, and as the kinetic theory could afford so little certain information, it might have seemed that we must rest content with the knowledge already attained. Speculation as to the nature of the atom was not wanting, ranging from the simple hard atom of the original theory to the centre of force of Boscovitch, and the vortex atom of Professor Thomson, the early speculation of one who has done, perhaps, more than any other to render possible a true theory of the atom. These theories, ingenious as they were, withered for lack of experimental support, and the subject became gradually to be regarded as being in the realm of the unknowable. Meanwhile the great success of the statistical methods of the kinetic theory, the extension of thermodynamics, and the study of phenomena from a consideration of their equilibrium conditions which followed on the work of Willard Gibbs, were leading further and further away from atomic and molecular hypotheses.

Fortunately one loophole remained into this region of the infinitely small. The kinetic energy of a particle is equal to the product of one-half its mass into the square of its velocity. However small the mass of the particle, therefore, we can theoretically by sufficiently increasing its velocity endow it with an appreciable amount of energy. In the case of a molecule the velocity required will, of course, be very large. The energy of a molecule in the air under normal conditions of temperature and pressure is about 5×10^{-14} ergs, assuming the mass and velocity already given. This is far too small to be detected. Let us suppose, however, that we can

endow our molecule with a velocity much greater than this, approaching 2×10^9 cms. per second. The energy of an oxygen molecule moving with such a speed would be $\frac{1}{2} (32 \times 1.61 \times 10^{-24}) \cdot (2 \times 10^9)^2$ ergs, or about 10^{-4} ergs. This, though small, is not less than can be appreciated in other forms of energy. Thus Lord Rayleigh has estimated that the faintest sound which can be heard transmits every second across a square centimetre of area at right angles to its path about 2.3×10^{-5} ergs. The energy in the faintest perceptible beam of light is not far different from this. Thus the energy of impact of a single molecule travelling with the velocity we have suggested would be comparable with the energy in a faint beam of light or a just audible sound.

The velocity ascribed to the molecule in this calculation might seem impossibly large. It is in fact about $\frac{1}{15}$ of the velocity of light, and a particle travelling with this speed would, therefore, cover the distance from the earth to the sun in 2 hours. Such particles, however, actually exist, and it is the discovery of these particles and the measurements made upon them that have led to the great advances in molecular physics which we are about to describe. Particles having this velocity are shot out in large numbers from radioactive bodies. To anticipate a little we may say that the α -particles from radium consist of atoms of helium shot out with a speed of this order of magnitude, and bearing a positive charge. Thus it is that a single α -particle is able to cause a flash of light when it strikes upon a screen covered with a suitable material.

The α -particles consist of helium atoms only. Velocities approaching that of the α -particles can be given to atoms and molecules of other substances by passing an electric discharge through them in the gaseous state at very low pressures. The phenomena of the discharge tube have indeed afforded the best means of investigating the properties of moving electrified particles, and we shall proceed to their consideration immediately.

In order to complete our survey we will anticipate so far as to say that the first experimental investigation of these phenomena led to results of a startling nature. Professor Sir J. J. Thomson, as the result of a brilliant series of researches and deductions, which may truly be said to mark a fresh era in the progress of science, showed that the most conspicuous set of particles in the discharge tube, namely, those constituting the cathode rays, had a mass not more than $\frac{1}{1800}$ part of that of a hydrogen atom.

It was found, moreover, that whatever the nature of the gas through which the discharge was passing, whatever the nature of the electrodes used, the mass of the cathode particle produced and the magnitude of the charge carried by it was always the same. These cathode particles, corpuscles or electrons, as they came to be called, must thus be regarded as forming an integral part of the atom of every kind of substance. They are therefore even more fundamental than the atom itself, since they form part of the material from which the atom is built up. The methods used in their investigation are similar in principle to those which have recently been applied

to atoms and molecules, but the special properties of the electrons rendered their experimental investigation less difficult than that of the atom or molecule, so that for a time it could truly be said that far more was known of the electron than of the atom itself. For these reasons we will commence our study of molecular physics with the consideration of the electron.

(To be continued.)

The Electrolysis of Nitric Acid Solutions of Copper.—

Mr. J. H. Stansbie has communicated details to the Faraday Society of which the following is an abstract:—

The object of the investigation was to find the cause of the failure of the current to completely deposit copper from nitric acid solutions of the metal. A platinum cathode thickly plated with copper was rotated in a solution of nitric acid containing less than 0.1 mgm. of nitrous acid, and was then allowed to remain at rest in a similar solution for the same length of time. In one pair of experiments 15.4 mgms. of copper were dissolved from the rotating cathode, and 3.4863 mgms. from the stationary cathode. This remarkable difference is no doubt due to increased action brought about by the accumulation of nitrous acid or nitrite in the layer of liquid in direct contact with the metal, which cannot take place while the metal is being rapidly rotated. No current was allowed to pass in either case.

In the electrolysis of nitric acid solutions of copper it is found that nitrous acid is formed in the solution, and that the presence of this compound prevents the deposition of the last traces of copper from the solution. The influence of the nitrous acid increases with the concentration of the nitric acid. This is shown by experiments with solutions containing varying weights of nitric acid to the same weight of copper. The copper left in solution was found to increase with the concentration of the nitric acid and the accumulation of nitrous acid in the solution. The presence of free sulphuric acid in the solutions retards the formation of nitrous acid, and it is probable that a nitro-compound is formed from the two acids which is less effective in promoting the dissolution of copper from the cathode than nitrous acid alone. It is quite clear that the rotating cathode is much more efficient than the stationary one, and that all but the merest traces of copper can be deposited from dilute nitric acid solutions containing sulphuric acid, if the cathode is promptly removed and washed, preferably while the current is passing and the cathode rotating. This can be done by directing a jet of water on to the cathode from a stationary wash-bottle while the beaker is being lowered to break contact, or by means of a tap funnel.

Iodine Factory Plant.—A Press announcement reports to the effect that a movement is on foot for the erection of an iodine factory on a large scale in the neighbourhood of Stavanger, Norway. It is intended that the factory shall be capable of treating large quantities of kelp from Jæderen, Lister, and Karmøyen, and that other products besides iodine shall be produced therefrom.

Two attempts are now being made in the United States to extract potash from seaweed on a commercial scale. One company treats about 40 tons of kelp daily, obtaining about 20 to 30 per cent. of potash from it. In California 550 lbs. of chloride of potash, 200 lbs. of sulphate of potash and 5 lbs. of iodine are obtained from 1 ton of dried seaweed.—*Board of Trade Journal.*

CHEMICAL ENGINEERING.

CONVEYING AND ELEVATING PLANT.

By J. G. DAVIS, B.Sc.(Eng.), A.C.G.I.

THE question of freight and transport is of primary importance in so many undertakings,

viewed from a commercial standpoint, that cost reduction in this direction, by the use of appliances of a special character for each class of work, has become a recognised necessity in most industries.

In the absence of innovations of the first order, the cost of actual production of an article, or rather of the labour neces-



FIG. 1.—LINE IN THE CORDILLERAS.

sary in the actual working up of the raw material, although open to considerable reduction by the employment of improved plant and process, is likely to remain at a fairly fixed figure. But that the cost of transport both between the various departments of the works, and subsequently to leaving the premises to the point of despatch, is capable of material reduction, apart from ordinary freight charges, there is ample evidence.

It is often such introduction of economies in the unproductive work that converts a previous loss into profits, and no undertaking can afford to neglect evident means of improving its condition financially.

The planning of a new works to secure minimum outlay in transport costs should be among the first cares of those responsible, whilst earnest consideration of the effect of introducing suitable conveying appliances into existing factories, with any modifications called for by such installations, is advisable.

The rapid advances made in the design of special elevators, conveyors, aerial ropeways, cableways, telfers, and the like, have become more

evident on the Continent and in the United States than in this country, but manufacturers and others are now realising the savings to be effected, and are following foreign examples.

Several firms here specialise in such plant, and the accompanying illustrations show typical examples manufactured by Messrs. Adolf Bleichert & Co.

Runways, aerial ropeways, and conveyors of various types are being turned out in considerable numbers by such firms as Messrs. Bullivants, Babcock and Wilcox, Leech, Goodall & Co., and Herbert Morris and Bastert.

The first named are the originators of the "wire rope," and have plant installed in most parts of the world, making a speciality of the steel hawser and its applications to ropeways and the like.

It is interesting to note that in a typical case the tenacity of the steel used for such a ropeway was found to be 27.5 tons per square inch, after over two years of hard wear in an exposed position, the test on installation having shown just over 29 tons tensile strength.

The replacement of the cable is generally necessary from considerations of wear alone, the deterioration of the reliable makes of wire rope being almost negligible.

The handling of coal and coke affords an extensive field for special apparatus, and many types have been designed for this purpose, the ash-tray con-



FIG. 2.—SHIP LOADING AND UNLOADING.

veyor, mechanical stoker, bucket-conveyor or dredger, and other kinds of conveying plant being

fairly familiar to most of us in the factory and its immediate surroundings.

But the increased use of runways to facilitate the handling of material throughout a works is newer, and the extension of these outside the area of the factory itself is of later adoption in the works of this country.

Wire ropeways have found numerous openings for the ready conveyance of ores, coal, cement, lime, fruit, timber, and other material, the cars being slung from a guided trolley on runners in the form of a pair of pulleys, and working simply by gravity. Either double wires or single ones (monocables) may be used for the purpose of providing an aerial track.

The cars for holding the material may, as an alternative, be provided with an electric lifting gear, but for long distance work, such as is illustrated in crossing the Argentine Cordilleras (Fig. 1) arrangements for lowering at the far end only are made.

The elevated ropeway here shown has a length of 34 kms., is some 4,500 metres above sea level at its upper end, having risen some 3,300 metres, and is subject to wide temperature fluctuations. In spite of heavy gradients and high winds the service is regular and quite satisfactory. This length is exceptional, most wire ropeways being erected to connect the works with the railway or waterway, where the raw material is brought in, or where despatch takes place for transport and such distances being medium.

The connection of elevated plantations with factories at the base of the hills and some considerable distance away, is, however, by no means uncommon, and in such cases the advantages of the aerial ropeway become most apparent, the nature of the ground being often very rough.

Fig. 2 is a good example of this, showing the loading of 250 tons of iron ore per hour from shore to ship. The line here might be of more rigid construction, namely a steel joist, as indicated in Fig. 3, allowing of the installation of electric conductors alongside to feed the travelling motion, and also the lifting motion, each by means of its own motor.

This constitutes the principle of the various systems of electric telpherage, the meaning of the latter phrase being "the transmission of vehicles to

a distance, independent of control from the vehicle."

Agricultural products, such as cotton, fruits, coffee, and such materials as sand, gravel, slag, clay, and others already mentioned, may be readily transported by such electric telpherage lines placed either overhead, underground, or on the surface, ravines, swamps, and inequalities of the ground



FIG. 4.—SHORE CRANES WITH MOVABLE JIBS.

being evidently no obstacle to direct transportation with the overhead system described. The addition of electrically-driven hoisting appliances to electric suspension railways is often omitted as not being of material value where the cars are loaded at one extremity of the line and simply discharge their contents at the other, but in many cases a large amount of labour can be saved by its action. The introduction of this in such a manner that the starting, stopping, and discharge of the cars can be automatically controlled over the whole of the system, collisions on the line, or at switches or crossings being prevented by an automatic blocking system, is now accomplished, the amount of attendance being reduced to that of the men stationed at the switches, and of those responsible for the treatment of the material on its discharge from the cars.

Profitable application of this electrically controlled system is possible even with small capacity plants, the wages accounts being greatly reduced. The type of car illustrated in Fig. 3 is applied specially for conveying coke from the retorts or coke ovens in gasworks. The coke falls from the retorts directly into perforated buckets of the pattern shown, standing in water. Having been thus quickly quenched, the electric hauling gear comes into operation, raising the bucket with its load of coke, leaving the water behind, and causing the travelling gear to carry the car to the dressing floor or storage depot. Here the load is discharged and the car returns, without intermediate handling, to the retort house.

Such suspension railways may be installed to run independently of all mechanical haulage wherever the necessary rail and sliding conductor to feed the current have been laid.



FIG. 3.—CAR FOR CONVEYING COKE.

Whether the simple runway, consisting of a pulley sheave mounted on rollers travelling on the lower flange of a joist and operated by hand in both horizontal and vertical motions, or an elaborate electrically controlled system is to be installed, however, depends upon the service desired and the facilities afforded for erection. It must be remembered that erection with a new factory will prove more economical and satisfactory than if the buildings already exist.

In connection with cranes and unloading appliances, much scope has been found for special apparatus, and Fig. 4 shows a representative series of shore cranes with movable jibs, designed for transferring material into railway trucks from ships alongside. The time factor becomes often all-important in loading and discharge of cargo, and prime cost of plant balanced against the savings effected not infrequently determine its installation.

Wire ropeway cars may be conveniently filled by cable hoists fitted with "grabs," which descend into the hold, open, fill and automatically close on lifting, and are automatically discharged into any ready receptacle at the will of the operator. Cable hoists are usually associated with large spans.

The types of belt and bucket conveyors for special kinds of work are numerous, the principal aim in all of them being to produce the desired motion of either a travelling band or belt running on pulleys or rollers, or of a chain or its equivalent, usually tooth-driven and carrying the material in a series of buckets with as little frictional loss as is possible.

These, as employed in mines or works, are familiar, the belt conveyors by Messrs. Leech, Goodall & Co. (late Graham, Morton & Co.), possessing certain special advantages in dealing with loose and irregular materials such as ores and coal.

There is a gravity bucket or tray conveyor constructed by Messrs. Babcock and Wilcox, which is adaptable for use as an elevator or conveyor and elevator combined. It consists of a series of trays fitted to chains of the kind used on an ordinary gravity bucket conveyor, and replacing the buckets so as to form a continuous moving platform. This is capable of delivering automatically ashes, coke, ores, and the like, without interruption or special filling appliances, and has a large carrying capacity in proportion to its cross section and price.

For a horizontal delivery only about one indicated horse-power is required to drive some 250 ft. of this conveyor, carrying 20 tons of material, per hour, any convenient method of driving being adopted.

This closely approaches the case of a belt-conveyor, but apart from its advantages in special cases its high efficiency from the point of view of energy cost is a point of note.

Rope and chain haulage plants have undergone considerable improvement during the past few years, and in connection with this it may be mentioned that where shunting is extensively involved, as in railway sidings, the installation of a "rope shunting" plant, in which the horse or locomotive is

replaced by a series of ropes in endless motion, may prove economical.

By hitching a truck on to the moving rope at any point it can be shunted as desired, with the obvious advantage that trucks standing between others and ordinarily inaccessible can be reached, and that several parts of the rope may be used simultaneously in this way, with little danger.

A comparatively recent type of bucket conveyor is worked by Messrs. Bleichert on a single rail able to take turnings of most kinds in buildings in a limited space. By electric control, intermediate handling of the material carried can be practically eliminated, as in electric suspension railways.

The turning of curves and corners can be very safely arranged in the latter, also, it should be stated, whether it be cable or steel joist carrying the cars, and this more neatly than in the ordinary type of belt or bucket conveyor, in which the power of changing direction horizontally is distinctly limited.

PERSONAL AND OTHER NOTES.

DR. WILLIAM PERKIN, F.R.S., has been elected to the Waynflete Professorship of Chemistry, in the place of Dr. William Odling, who resigned that Chair last Summer term. A Fellowship at Magdalen College is attached to the Professorship, to which Professor Perkin was recently admitted. He is the son of the well-known chemist, Sir William Perkin, and was educated at the City of London School, the Royal College of Science, and the Universities of Würzburg and Munich, at which last University he was for three years. *a Privat docent*. From 1887 to 1892 he was Professor at the Heriot Watt College, Edinburgh, and has been Professor at Manchester since 1892. Convocation last month voted a site in the University park for a new chemical laboratory, and the trustees of the Chancellor's Endowment Fund have provided £15,000 towards its erection.

Dr. T. Martin Lowry has been appointed Lecturer on Chemistry at Guy's Hospital Medical School.

At the anniversary meeting of the Royal Society, held on November 30th, the following were awarded the Society's medals:—The Rumford Medal to Dr. Heike Kamerlingh Onnes, of Leyden, in recognition of his contributions to low-temperature research; and the Davy Medal to Professor Otto Wallach, for his researches in organic chemistry.

Professor P. Sabatier, Professor of Chemistry at the Toulouse Faculty of Sciences, has decided, reports the *Chemist and Druggist*, to give his portion of the Nobel Prize to the Toulouse Institute of Chemistry.

We learn with regret of the death of Dr. G. B. Neave, Senior Lecturer in the Chemistry Department, Glasgow, which took place on December 8th.

We regret to announce the death of Mr. Henry de Mosenthal, F.I.C., whose work in connection with explosives and research on cellulose is so well known.

NOTES ON CHEMICAL ENGINEERING.

By J. W. HINCHLEY, A.R.S.M., WH.Sc., F.C.S.

CHAPTER I.

SIZE—REDUCTION OF SOLID MATERIALS.

PRACTICALLY all solid raw materials and many finished products of the chemical manufacturer must be reduced to some degree of uniformity in size, determined ultimately by economic considerations. Many raw materials are reduced in the first instance by the hand hammer, either because the careful sorting which may be necessary to prevent subsequent loss can readily be given by this means, or the production of "smalls" can only be adequately avoided by hand work, or, the quantity to be treated is too small to pay for the installation of special plant. One man can usually reduce hourly from one quarter to one half of a ton of large lumps to pieces passing through a $2\frac{1}{2}$ in. diameter ring, and the cost may be taken as twice that of machine work, viz., 8d. to rs. 4d. per ton, according to the hardness of the material.

In all chemical operations, whether coarse or fine reduction is necessary, there are economic limits of size which give the maximum return. These limits for economic efficiency do not necessarily coincide with those giving the greatest chemical efficiency. In other words, the lowest "cost of production" is not always obtained by conditions which give the most efficient reactions.

All size-reduction machines operate in one or more of three distinct ways, by crushing, by grinding, or by impact. Rock-breakers and crushing-rolls reduce the material mainly by simple compression—*crushing*; in mill-stone mills, roller and other paint mills, the particles are mainly subjected to shearing stresses—*grinding*; and the disintegrator breaks up the material by means of blows on the unsupported grains—*disintegrating*.

In determining the size, capacity and power required for the size-reduction of different materials by different machines, the factors which enter into the calculation are so variable that it is necessary to allow a considerable margin. The compressive strength of the material to be crushed commonly varies from one half to twice its average value, and materials of the same character and composition from different localities may vary from one-eighth to four times the average value. It must also be borne in mind that the compressive strength is apparently greater in small than in large pieces of material.

Since the real work of crushing must be proportional to the amount of new surface produced, this work will vary directly with the compressive strength of the material and inversely with its density. An additional factor which is difficult to estimate enters into the problem, viz., the average amount of deformation which takes place before fracture occurs. Other properties of materials, also, complicate the

problem to such a degree that judgment and experience often become a safer guide than deductions from theoretical reasoning; such properties as hardness, tenacity, greasiness, and structure when exhibited in considerable degree, usually necessitate practical tests on a semi-factory scale before a sound judgment may be reached.

It is convenient, however, in making calculations on crushing and grinding to take a material as a standard and compare other materials with it. Limestone having a compressive strength of 10,000 lbs. per sq. in. is a very satisfactory standard. Simple factors may then enable one to estimate with practical closeness for the provision of grinding plant. Such a factor for chalk would range from '1 to '4 for compressive strength, for limestones; dolomites and sandstones, from '4 to 3; for granites, quartzites, etc., from '5 to 3; and for pyrites from '1 to 4.

The efficiency of crushing and grinding plant is always comparatively low on account of the power lost both in the machine and in the material. Some of the lost power appears in the material ground

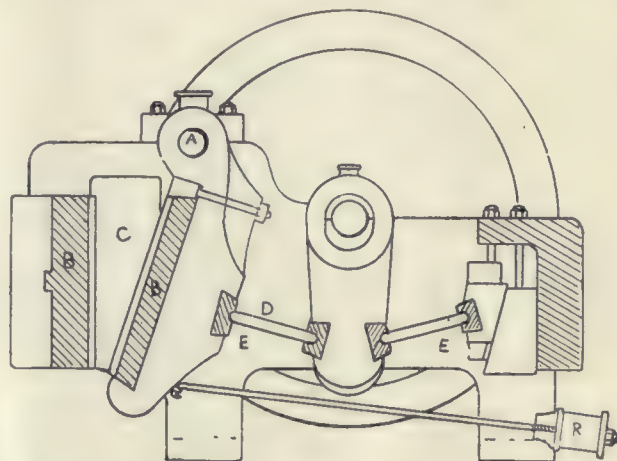


FIG. 1.

from the wearing parts of the machine; much is evident as heat in the machine, the material and the air; some is lost by plastic and unrecovered elastic deformation of the material, and the useless production of dust; and some, also, is evident as sound. For noisy machinery is always associated with inefficiency.

The statement that the amount of new surface produced by crushing or grinding is a measure of the real work performed by a size-reduction machine, enables one to calculate outputs provided that we have some notion of the efficiency of the machine under consideration. Factory results show that the amount of work done compared with the area of the fractured surface is constant for coarse sizes, but

with fine grinding, the amount of new surface produced is greater than indicated by the above generalisation. This difference is, no doubt, largely due to the effect of the previous coarse crushing in deforming the particles and producing incipient fractures and thus facilitating the finer reduction.

This rule may be stated thus:—

H.P. required per unit weight per hour =

$$A \left(\frac{1}{d_2} - \frac{1}{d_1} \right),$$

where d_1 is the average diameter of the particles fed to the machine, d_2 the average size of the ground product and A is a constant for the material. The value of A may be calculated by reducing a sifted quantity of the material, measuring the power, and sizing the

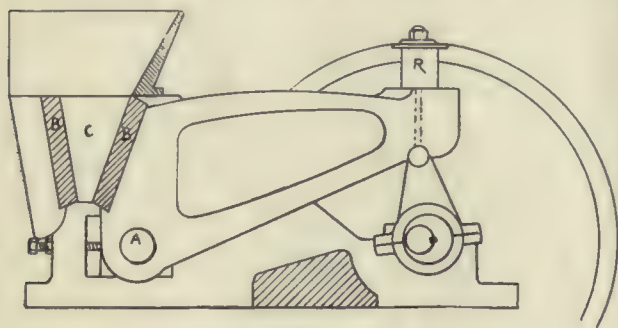


FIG. 2.

finished product. If the product is very variable in size then $\frac{1}{d_2} = \frac{a}{d_3} + \frac{b}{d_4} + \frac{c}{d_5}$ where a, b, c are factors showing the amount of each diameter present in unit weight of the product, and d_3, d_4, d_5 are the respective diameters. The machine in which the test is made should be worked at or have the same efficiency as that to be used, or a correction must be introduced to cover this error.

Coarse Size-Reducing Machines: Rockbreakers.—This class of machines depend upon the lumps being crushed between a fixed surface and a surface which approaches and then recedes from the fixed surface. The simplest type, usually called a "jaw-breaker," in which the surfaces are plane, has a moving jaw which swings on horizontal bearings. The gyrating type in which the surfaces are circular has a conical head mounted upon a gyrating spindle so that when one part of the surface is approaching and crushing the opposite part is receding and allowing the product to fall for new material to take its place. Such machines have the advantages of large output and continuous action.

In the jaw-breaker type the hinge A of the jaw may be near the mouth of the machine as in the Blake Crusher (Fig. 1), near the outlet as in the Dodge Crusher (Fig. 2), or the moving jaw may be actuated by levers in such a manner as to produce a rolling action as in the Samson Crusher (Fig. 3) and other makes.

The advantages of one class of machine over another is not very pronounced provided that the design is strong and the quality of workmanship good. The action of the Blake Crusher is excellent,

but the product is not so regular in size as that from the Dodge Crusher. On the other hand the Dodge Crusher is noisy and must be fed evenly or choking takes place with the production of much fine material. The stresses in the Dodge Crusher are higher than in the Blake and the mechanical efficiency is often lower in consequence. The output from the gyrating type is very large indeed but the product is more irregular than that from the Blake.

In the jaw-breaker type the movement of the jaw varies from $\frac{1}{8}$ in. at the point of smallest movement to $\frac{1}{2}$ in. at the point of greatest movement, and the speed may be from 250 to 300 revolutions per minute. The performance of different machines may be approximately compared by the area at the mouth. The angle between the jaws must be considerably less than the angle of friction for the material, or the lumps to be crushed would jump out, and is usually about 18 degrees. The adjustment for the size of product is made by moving the lever bearings or jaw bearings by means of screws and wedges. As

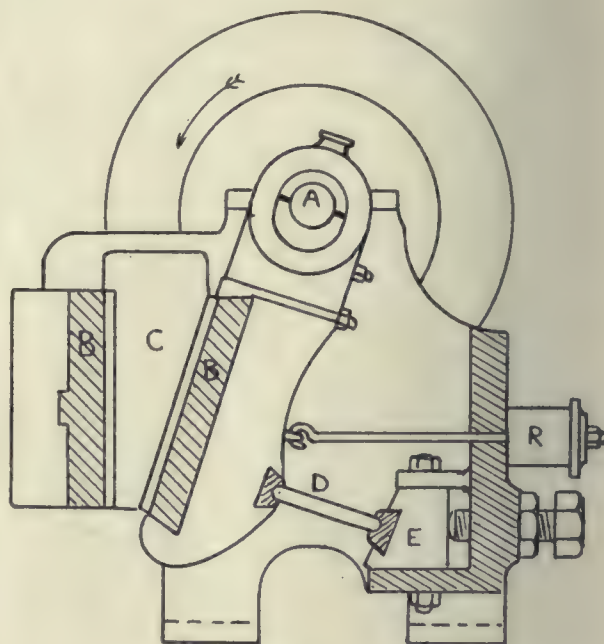


FIG. 3.

a rule 1 cwt. of standard material may be crushed per hour from 4-in. to 2-in. cubes per square inch of mouth opening, i.e.,

Output in tons per hour = $.05 A$, where A is the area of the mouth in square inches. The horse-power required for the work will be $.1 A$ and the price of standard machines is approximately = $\pounds (.8 A + 30)$.

The frames of these machines must be absolutely rigid, and there is little doubt that cast-iron, from the economic and utility point of view, is the most satisfactory. Cast-steel or built-up frames are often recommended, but their use should be restricted to places where transport and erection are costly and difficult. The design should be as simple as possible, for additional levers mean extra strains and more energy loss. The desire to obtain a good hammer action is often responsible for complication without

any balance of advantage. The mouth and jaws should be machined so that new jaw plates, etc., can be fitted without trouble, and provision should be made so that wear can be equalised either by turning the jaw plates upside down or by making them in parts. The jaw plates B and side plates C are usually made of hard steel or chilled cast-iron. Manganese steel, when of good quality, is undoubtedly the best material for wear and tear, but in chemical work it is doubtful whether it shows any economic advantage over chilled cast-iron. The working faces are V-grooved vertically to reduce the work of crushing by applying the forces at definite points and to diminish the amount of "smalls" by avoiding grinding action.

The jaw and other plates are usually fixed by wedge-headed bolts and bedded into place by means of molten zinc or white metal. A better way of bedding the jaw-plates is to provide recesses at their backs to carry plugs of white metal of some standard form, which squeeze and finally equalise the pressure all over the jaws.

Large bearing areas on the bearings and pro-

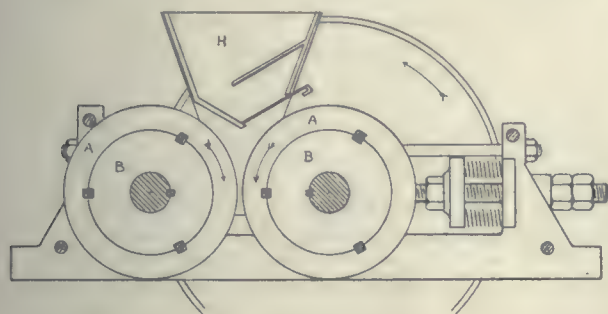


FIG. 4.

vision for lubrication which has little risk of admitting grit to the bearings are points of great importance. With best workmanship gun-metal or phosphor bronze bearings are better than any other, but where rough repairing is likely to be met with white metal faces to the bearings are desirable.

Ease of operation also depends to a large extent on the careful fitting of the toggles D and joints E. The fly-wheel power should be sufficient to ensure a good hammer action, *i.e.*, steady running. Some safety arrangement must be provided so that when a piece of metal falls between the jaws a replaceable breaking piece, key, pin, etc., gives way before any other damage is done.

A good foundation for such machines is a distinct advantage, but is not essential to good working.

The life of such machines may be taken as ten years, and the cost of renewal of jaw plates at from 1*d.* to 2*d.* per ton of material crushed.

Medium Size Reducing Machines; Crushing Rolls.—Rock-breakers are not very efficient machines for materials smaller in size than 1 in. (the Samson machine, however, reduces efficiently to $\frac{1}{2}$ in. size), and medium size-reduction is usually made by means of crushing rolls. They consist (Fig. 4) of two cylinders which, by revolving towards each other,

draw and crush lumps of material between them. Such rolls must run at the same peripheral speed or grinding action with excessive dust production occurs.

Crushing rolls may be worked either wet or dry, and are most efficient for reducing down to .015 in. For finer reduction than this, ball mills, tube mills, and disintegrators are more suitable.

The peripheral speed of crushing rolls varies in practice from 30 to 1,000 ft. or more per minute, and although the size and character of the material has a determining effect on these speeds, the mechanical construction has a greater.

High speed rolls are only possible when each roll is belt-driven separately. Where the rolls are geared together mechanical difficulties compel a reduction of speed and a low efficiency is obtained.

An estimate of the most suitable speed for rolls for a given material is:—

$$S = 1,000 - 300 \log_{10} d,$$

where S is the peripheral speed in feet per minute, and d is the diameter of the particles of fed material in $\frac{1}{100}$ of an inch.

It will be obvious that there is some relation between the maximum size of particle and the size of the rolls so that slip shall not occur. The considerations which apply to the angle between the jaws of jaw-breakers apply here. As a rule the rolls are set to a distance apart equal to the size of the finished product, and held in position by means of springs which give way when hard foreign substances are accidentally fed.

The angle between the tangents at the points which the largest fed particle touches the rolls is called the angle of nip and is usually for ordinary materials 30° to 32°. Taking the best angle of nip as 32° then

Diameter of rolls in inches = $25 (.96 d_1 - a)$, where d_1 is the size of the fed particles in inches and a the distance in inches between the rolls.

The actual output of rolls is capable of approximate estimation. If f be the ratio of the width between the rolls to the diameter of the particles of charged material, *i.e.*, $f = \frac{a}{d_1}$, A, the area of the opening in square feet and S the peripheral speed of the rolls in feet per minute then—

Volume of material passed in cubic feet per minute

$$= AS (.6 f + .15).$$

Knowing the weight of a cubic foot of the material, it is a simple matter from this to determine the weight per hour which may be expected as the output for the machine.

(To be continued.)

Scientific Diary.—We have received from Messrs. James Woolley, Sons & Co., Ltd., of Manchester, dealers in scientific apparatus, etc., their 1913 issue of the "Scientists' Reference Book and Diary." This small and compact pocket-book contains important data of an interesting character.

ASBESTOS: ITS ORIGIN AND PRODUCTION.

THERE are at present three known groups of commercially valuable asbestos minerals; they are (1) Anthophyllite group, having the chemical composition (Mg.Fe) LiO_8 (2) Amphibole, or hornblende group. This group has the chemical composition RSiO_8 , usually associated with iron and manganese, sodium and potassium; (3) Serpentine group having the composition 3MgO , 2SiO_2 , $2\text{H}_2\text{O}$. The composition of asbestos from different parts of the world differs considerably, as the following four analyses from America, Italy, and Cyprus indicate:—

	Cyprus.	Italy.	Thetford, Canada.	Templite.
SiO_2	40.5	40.30	40.57	40.52
Al_2O_3	1.09	2.27	0.90	2.10
Fe_2O_3	4.87	0.87	2.81	1.97
MgO	39.02	43.37	41.50	42.05
Water	13.47	13.72	13.55	13.46

The notable point of these figures is the large amount of water, the greater it is the better and finer is the quality of the asbestos; with a smaller percentage of water the fibre becomes brittle and will not spin. Canadian asbestos is considered the best and provides 75% of that required throughout the world; but the above figures show that the water percentage is as great in asbestos obtained from Cyprus and Italy, but the former has a larger percentage of Fe_2O_3 and less MgO . The Greeks named the fibre "asbestos" unconsumable; the Romans made cremation robes of it; and it is related of Charlemagne that he astounded his courtiers by throwing his tablecloth into the fire and withdrawing it white and clean. Asbestos has therefore been known and used for some thousands of years. The conditions under which asbestos is formed in nature are extremely complex; it is found associated with certain easily recognised igneous rocks which occur in many parts of the earth, including this country, Italy, Cyprus, Russia, Siberia, Canada, the United States, and many others. Formerly the world depended on Italy for its supply, now the bulk comes from Canada, and in the district producing asbestos the rocks containing it consist of highly crystalline peridotite, pyroxenite, gabbro, diabase and some others. Some of these rocks also occur in this country, such as gabbro, which crops out in the Isle of Man, but does not contain any asbestos. Fibrous asbestos is supposed to have been produced as follows: The peridotite when altered by hydrating is known as serpentine. During the cooling of this rock we may suppose cracks to have been formed and that the hydrating process, which caused the rock to take water in its structure widened these fissures. During the hydrating action the water carrying some of the serpentine in solution collected in these cracks and eventually the dissolved mineral formed thread-like crystals, usually building up from opposite walls of the crack and meeting or forcing past its other at the centre. The cracks filled with the asbestos fibres are usually straight, but do not occur in parallel planes; they are found crossing each other and running in all directions.

The amphibole or hornblende asbestos does not possess the fineness of fibre, the tensile strength, the elasticity or flexibility of the chrysotile variety, both are equally heat-resisting. The amphibole differs from the chrysotile in its chemical composition, the latter is a silicate of magnesia and is always hydrated; the former has lime combined with its

magnesia and may be only slightly hydrated, or in some cases not all. The waterless varieties are not suitable for spinning and weaving as they are too brittle; but they can be ground up, formed into a paste, subjected to pressure and manufactured into fire-resisting, or heat-containing materials suitable for many industrial purposes. The chemical constituents of the parent rock, serpentine, and the asbestos it contains are very similar, as the following comparative analysis will show:—

	Serpentine Rock.	Canadian Asbestos.	Amphibole Variety.
Silica	40.34	41.90	61.82
Magnesia	43.32	42.50	23.98
Alumina	1.32	0.89	1.12
Ferrous oxide	1.23	0.69	6.55
Water	14.17	14.05	5.45

The amphibole variety has in addition to the above 1.63 of lime. The Canadian asbestos is a chrysotile. The marked differences of the water contained, 14.05 for the Canadian variety and only 5.45 for the amphibole are notable, as that renders the fibre commercially useful; its softness appears to be proportionate to the water percentage. Very silky fibre may contain 15% of water; brittle and harsh asbestos may have only 11% or much less. That this is so may be experimentally proved by subjecting very soft fibre to a high temperature, which drives off a portion of the combined water: the fibre then loses its flexibility and cannot be spun. It may be assumed that all asbestos deposits had originally the same large percentage of water, and that some have been subjected to great heat since they were formed and their compositions have been thus modified in various degrees by losing a greater or less percentage of water. Examined under the microscope asbestos is an interesting material, at about 90 diameters the sub-divisions of the fibres seem to be unlimited; the bundles break up and branch off into numberless finer fibres. With a power of 900 diameters, fibres appear which are barely discernible and which may be estimated to be 5 1-1,000,000 inch in diameter. There is no reason for supposing that these extremely fine fibres may not be capable of still further sub-division. There appears to be scarcely any limit to this possible sub-division. Mica is another mineral capable of almost indefinite sub-division.

The physical characteristics of the asbestos fibres are interesting and have caused great difficulties to those who first attempted to put them to practical use. Other fibres such as wool, cotton, and silk have more or less rough surfaces, so that when they have been spun into a thread they hold together; but asbestos fibres have a perfectly smooth surface, that appears to be the essential difference between a mineral fibre and one of animal or vegetable origin. For a long time this peculiarity rendered it impossible to spin asbestos fibres. Now that the difficulty has been overcome strong thread weighing about one ounce to the 100 yds. is in ordinary use. When asbestos has been opened out into a flossy mass the crystals appear to be white but when embedded in the rock the compact fibres may have a great variety of colours: yellow, various shades of green, from pale to blackish, blue, brown, grey, salmon, and many intermediate shades.

We depend for our main supply on the quarries in the neighbourhood of Quebec; up to about 1875 nearly all the asbestos used throughout the world came from Italy, but the cost of producing it, due to the local difficulties of mining

made it too costly for general use. The Canadian supplies are obtained from serpentine rocks, which occurs in a relatively narrow zone extending from about 40 miles south of Quebec, to and across the United States frontier. It is also worked in the States. Asbestos occurs in many parts of the world, but the quality is not always such as to make it commercially useful. Deposits also occur in Newfoundland in the vicinity of Port Bay, but as the locality is very inaccessible, they have not therefore been opened out. Asbestos also occurs in Russia, Siberia, Finland, Cyprus, Queensland, South Australia, New South Wales, New Zealand, Rhodesia, California and China. A lavender blue fibre is obtained in South Africa, which differs from other varieties both in colour and specific gravity, which is lower; it has great strength and may compete with the Canadian variety.

The fibres may be divided into four well-marked groups. The cross fibre, which is of the greatest commercial importance, occurs in distinct veins and extends from wall to wall of the serpentine. The centre of the fibre is marked by a film of magnetite or chromite, from which the chrysotile grows exogenously into the walls of the serpentine. The fibres vary in length from a fraction of an inch to two inches in length. The slip fibres run parallel with the fracture planes produced by the crushing and shearing of the rocks. Such sheared or shaley serpentine frequently carries more fibre than the cross fibre rock; but it is not equally well adapted for useful purposes. The third group or variety is known as mass fibre; as the name suggests it does not occur in fissures, but in masses. When these are found the other varieties are rare, or are entirely absent from the rock. The conditions which produce mass fibre are different from those producing cross and slip fibres. The last variety is known as shear fibre, made up of cross fibres, which have been sheared by a subsequent movement of the rocks. The fibres are found lying parallel with the fracture planes, but evidently altered in direction after their formation. These shear fibres are of equal strength, fineness and flexibility with the best cross fibre. These shear fibres may sometimes extend to a length of 6 ins. The very best variety of asbestos, with the highest percentage of water is known as chrysotile, from the town of that name in Vermont, the United States, where it is found in quantity. It is difficult to account for the water necessary for the formation of asbestos. In the process of transition from peridotite to serpentine in which the asbestos occurs water is essential; its source is not known, but these two possible ones, which appear to play some part in the process: It is known that water circulates very freely through the rocks and where springs and brooklets appear in the serpentine, then serpentinisation is the greatest. Some of the longest asbestos fibres have been found in these channels. The introduction of either acid or basic intrusives would bring in magmatic waters. There are at least two periods of intrusion. First the peridotite itself and then the later introduction of the diabase. Mineralogically, asbestos is a general term. The Romans applied it to the fibrous members of the amphibole family such as tremolite, actinolite and crocidolite, whilst modern writers apply it to the delicately fibrous and silky chrysotile. The former contain 1, 2 to 5% of water of crystallisation, while the latter contain from 12 to 15%.

The theory for the formation of asbestos is broadly as follows: Among volcanic rocks are a series known as peridotite. These through causes which need not be discussed here, become fractured, the fracture is filled with film of magnetite, on each side of which a process of serpentinisation takes place, that is the peridotite is changed for several

inches each way, the serpentine formed gives rise to the asbestos crystals which spread outwards from each side of the film of magnetite. The essential factor is the purity of the parent rock peridotite, it is anhydrous, whilst the serpentine is hydrous, access of water is essential. The serpentine formed having taken up 12 to 15% of water is softer than the parent rock. After the serpentine has been formed a portion of it is crystallised forming asbestos; the remaining portion remains amorphous. Thus the following sequence may be found: First a film of magnetite marking the commencement of the process, on either side $\frac{1}{2}$ to 1 in. of asbestos crystals, beyond which in each side are $1\frac{1}{2}$ or more inches of serpentine, with the parent rock peridotite enclosing the whole. The crystallisation is always proportionate to the serpentinisation, and a well serpentinised rock may contain 15% of asbestos. The process of crystallisation requires water and heat. In a suitable district the quantity of asbestos will in the main depend on the extent of the fracturing of the rock, as it is along the lines of the fractures that the processes giving rise to asbestos take place. The essential qualities which render asbestos useful are its flexibility, fibrous structure, as well as its incombustibility and slow conduction of both heat and electricity when the mass is fiberised, which render it extremely useful not only for fireproofing, but also for insulating against heat and electricity. Asbestos is both spun and woven to make incombustible thread, rope and cloth, and, as has been already stated, its value for these purposes was known to the ancient Greeks and Romans. It may confidently be stated that the demand for asbestos for many useful purposes will increase, new applications will be made for a material possessing the qualities specified above. In the mechanical arts its value is now indispensable, and as a building material its use is rapidly extending. Electricians use it largely where insulation is required, as in the handling of heavy electrical currents no other material is so well adapted as asbestos when manufactured into insulators, switch boxes and similar appliances. It is not affected by most chemical agents which attack insulation; it is also most useful as a covering for piping in connection with refrigerating plants as well as for steam pipes, boilers, and wherever prevention of radiation or cooling is required. It is made up into a paper or felting for building purposes, and in combination with caustic lime it produces a perfectly fireproof wall plaster for either inside or outside work. A fireproof brick is now, manufactured where high temperatures are required, composed of asbestos sand and hydraulic lime, suitable for lining furnaces and fire boxes. Asbestos has been woven into conveyor belts for conveying hot clinkers and other substances.

It may be assumed that 100,000 tons are now required to supply the world's demand, of which 75,000 tons come from Canada, where some of the mines are worked continuously 24 hours per day. There are very few underground workings, most of the work is daylight mining in open quarries, some of which have attained enormous dimensions. To prepare asbestos for use the adhering rock has to be removed and the ore is heated to drive off moisture; when dried the ore is passed through crushers, which break the bundles of fibres until they are pulled apart. Imports of raw asbestos into this country were 138,000 cwt. last year, coming mainly from Russia, United States, Cape of Good Hope, Canada, and in smaller quantities from other countries; of which we re-exported 31,000 cwt. Of manufactured asbestos goods our imports last year reached £223,000 in value, and we exported goods made in this country to the value of £83,000.

* REVIEWS OF BOOKS. *

"THE PREPARATION OF ORGANIC COMPOUNDS."

By **E. de Barry Barnett**, with 50 Illustrations, 301 pages, with a table of Contents and Index. J. and A. Churchill, London, 1912. Price 8/6 net.

THIS book is another contribution to the increasing number of works dealing with the preparation of organic compounds.

In the text-books of organic chemistry published some thirty to forty years ago, such as those of Fownes (revised by Watts & Tilden), Ira Remsen, and Emerson Reynolds, a number of experiments, illustrative of the subject-matter of the text, were to be found, and when these experiments were conscientiously carried out, great good resulted, because their purpose was well defined.

Later on, it was felt that these experiments were not sufficiently numerous or comprehensive for modern teaching and examination requirements, and soon the want was more or less supplied by the publication of books dealing with this branch of practical chemistry. Unfortunately, it is to be feared that in many cases these "preparations" were carried out without due consideration being given to the object of such work, and the students' note-books were simply a collection of recipes. The instructions given in the books were so full and complete that little was left for the exercise of any initiative that the student might possess. The author of the present work appears to recognise the existence of this fault and has made an attempt to remedy it.

We differ from him in some of the practical details of some of the preparations, but they are perhaps unimportant.

A feature of the present work is the inclusion of a considerable number of preparations taken from the patent literature, and this should be good training for those taking up positions as works chemists. In the right key, too, is the suggestion to use homely apparatus for many of the operations instead of the fragile beaker, etc. Domestic jam-pots and saucepans are serviceable things in the laboratory. Common reagents such as sulphuric acid and caustic soda receive consideration, and we agree with the author that chemicals of technical purity are sufficient for most purposes. The author stipulates that his book is not intended for those who are studying chemistry away from a university or technical college or without the aid of an experienced senior student or teacher, but we believe that there are many persons studying privately who, with a little common sense, will be able to carry out many of the preparations described.

The author has arranged the subject-matter on orthodox lines, commencing with the hydrocarbons, the halogen compounds, alcohols, phenols and mercaptans. Needless to say, the author

does not recommend the preparation of the mercaptans. The preparation of the two technically important, thioglycollic and thiosalicylic acids is described. Instructions for the difficult preparation of mannose phenyl-hydrazone are given.

Some of the quantities of materials recommended seem to us excessive; for instance, in the preparation of aceto-acetic-ester, 250 gms. of ethyl acetate are recommended to be taken. Grignard's reagent is described and some of its applications illustrated. Preparations involving intramolecular rearrangement are described.

Compounds containing nitrogen receive a fair share of attention, the diazo-compounds, dyes, etc., forming interesting chapters.

We can cordially recommend this book to the notice of teachers and students.

F. W. S.

"GENERAL FOUNDRY PRACTICE." By **Andrew McWilliam and Percy Longmuir**. Second Edition. CHARLES GRIFFIN & Co., Ltd., London, 1912. Pages 384 + 111, including Index. Chapters XXXVIII., including Numerous Illustrations. Price 15/- net.

This work has met with success and a second edition has been called for, and is now produced.

A feature of this work is that the authors have from practical experience produced a text-book which is of real value to the practical worker as well as the student and manufacturer. This is specially seen in the sections which deal with such matters as shrinking, contraction, and warping, faults due to mould and pattern, mixing by analysis, and similar subjects.

There can be little doubt but that this second edition, with its additional matter and illustrations, will meet with equal success.

"METHODS OF SUGAR ANALYSIS AND ALLIED DETERMINATIONS." By **Arthur Given**. P. BLAKISTON'S SON & Co., Philadelphia, 1912. Pages 75, including Index. Divided into thirteen sections, with 8 Illustrations. Price \$2.00.

The author points out that the A.O.A.C. methods are not sufficiently explicit as to the proper method to be adopted in a particular case. This work will be found useful, as it contains much information which is based on practical experience. The sections dealing with cane juice, maple syrup, and honey are particularly valuable, and the food chemist and others interested in the analysis of products containing sugars cannot fail to gain information from this work.

"A SCHEME FOR THE DETECTION OF THE MORE COMMON CLASSES OF CARBON COMPOUNDS." By **Frank E. Weston**. LONGMANS, GREEN & Co., London, 1912. Third Edition. Pages 108. Divided into sixteen sections, with 22 Illustrations. Price 3/-.

The third edition of this useful work, which contains certain additions, including the identification of aldehydes and ketones, and other matters, increases the value of this book, which certainly meets all the

requirements of the average student. We have no hesitation in adding our praise to that which has been given to the previous editions. It is an extremely useful compilation.

"RESEARCHES ON CELLULOSE, 1905—1910," No. 111. By C. F. Cross and E. J. Bevan. LONGMANS, GREEN & CO., London, 1912. Pages 173 + vi, including Index. Chapters V., including Bibliography. Price 7 6 net.

This further *résumé* of work in connection with cellulose, which brings data up to the year 1910, is fully up to the standard of the previous volumes, and forms an indispensable aid to the English-speaking chemist. Certain interesting chapters deal with cellulose in relation to biological science, constitution of normal cellulose, cellulose esters, ligno-celluloses, and certain technical developments. An index of authors and one of subject-matter completes the volume.

It almost goes without saying that this volume has an interest to all those connected with the research side of the many cellulose industries which exist, or are in process of actual formation.

BOOKS RECEIVED.

"A Dictionary of Applied Chemistry," by Sir Edward Thorpe. Revised and Enlarged. Longmans, Green & Co., London, 1912. Vol. III., GR—OILS. Pages 789 + viii. Numerous Illustrations. Price 45/- net.

"An Introduction to Mathematical Physics," by R. A. Houstoun. Longmans, Green & Co., London, 1912. Pages 199 + ix, including Index. Chapters VI. Price 6/- net.

"The Principles of Applied Electrochemistry," by A. J. Allmand. Edward Arnold, London, 1912. Pages 547 + vi, including Index and Appendices. Chapters XXVIII., including 136 Illustrations. Price 18/- net.

"Electroplating," by W. R. Barclay and Cecil H. Hainsworth. Edward Arnold, London, 1912. Pages 399 + v, including Index and Appendices. Chapters XIX., including 62 Illustrations. Price 7/6 net.

"Second Stage Practical Inorganic Chemistry," by W. Briggs and R. W. Stewart. University Tutorial Press, Ltd., London, 1912. Pages 206 + xv, including Index. Chapters IX. Divided into 2 Parts. Price 2/6.

"Lecture on Thorium and its Compounds," by Edmund White. Published by the Institute of Chemistry, 1912. Pages 27, with 3 Illustrations. Price 2/6 for non-members.

"Modern Laundry Work," by Ellis Clayton. Simpkin, Marshall, Hamilton, Kent & Co., Ltd., London, 1912. Pages 366 + viii, including Appendix and Index. Divided into 2 Parts, with VIII. Chapters, and 139 Illustrations. Price 12 6 net.

"Methods in Chemical Analysis," by F. A. Gooch. Chapman & Hall, Ltd., London, 1912. Pages 536 + xii, including Indexes. Chapters XII., with 29 Illustrations. Price 17/- net.

"Scientific Method; Its Philosophy and its Practice," by F. W. Westaway. Blackie & Son, Ltd., London, 1912. Pages 439 + x, including Appendix and Index. Divided into 4 Sections, with XLII. Price 6/-.

"First National Mine-Safety Demonstration at Pittsburgh, Pa.," by Herbert M. Wilson and Albert H. Fay. Bulletin 44, Bureau of Mines. Washington, U.S.A., 1912. Pages 75, including 4 Figures, and 7 Plates.

"The Scientist's Reference Book and Diary, 1913." J. Woolley, Sons & Co., Ltd., Manchester. Price 2/-.

NEW METHODS OF ANALYSIS.

HINTS ON MICROCHEMICAL ANALYSIS.

By ERNEST FEILMANN, Ph.D., F.I.C.

IN connection with certain industries, and certain lines of research the application of microchemical methods of investigation is very useful if not indispensable. As is well-known, these methods ultimately depend on obtaining the elements to be identified, usually in the form of their compounds, in forms, preferably crystalline, which admit of ready and certain identification in minute quantities in the field of a low power microscope.

Such methods are mainly of value for the detection and identification of elements already suspected; even in the case of a minute quantity of material of absolutely unknown origin and composition, the main constituents can usually be identified by microchemical means, at the expense of great care and of some time, but the elaborate schemes for the complete qualitative analysis of small quantities of material described in some of the text-books, should, in the writer's opinion, be accepted with considerable reserve as a practical guide, and to state, on the grounds of purely microchemical methods alone, carried out on small quantities of material, that any particular element is *not* present, is in many, if not most cases, a very doubtful proceeding. The reasons for caution in this respect are very numerous; there are mechanical difficulties connected with the separation and washing of several successive minute precipitates, which are difficult to overcome, even with the help of centrifuges and of much manipulative skill; there is the further difficulty that the work must necessarily be carried out in highly concentrated solutions, in which all manner of supersaturation phenomena, abnormal crystallisations and other sources of confusion are liable to occur; soluble double salts of exceptional solubility may be formed with excess of the reagents or with the other compounds present, and in fact a complete scheme for the analysis of a definite complex mixture by such means would involve the execution of a special research.

In such cases, however, as the examination of the deposits on the bulbs of electric lamps, small quantities of lamp filaments, fragments of glazes or enamels and the confirmation of the composition of minute precipitates obtained in the ordinary course of analysis—all cases in which the analyst has a fairly definite notion in advance as to what he is to look for—microchemical methods are invaluable, and the results, if carefully interpreted, afford information which is of a most definite character. If, under the influence of definite reagents, crystals of definite habitus with well-defined measurable angles, and behaving in a definite, measurable manner, under the action of polarised light, are obtained, which again in turn behave characteristically, still under the microscope, with specified reagents, then the accumulated evidence of identity is usually quite as strong as that shown by the constant melting point, and so on, of the organic chemist.

Owing to the great delicacy of the reactions, it is most necessary, in microchemical work, to test all reagents with the greatest care, preferably by microchemical means, and

indeed, in crucial cases, to carry out a complete blank experiment in advance, using not merely the same reagents, but also the same utensils, for porcelain capsules may yield alumina or lead, platinum may give off copper or other metals with which it has become contaminated, and glass, including microscope slides, may easily impart traces of half a dozen or more elements to warm acids or alkalies; for this reason it is often advisable, for delicate work, to use slides made of celluloid, which serve very well on the whole, though they offer the objection that they are usually far from homogeneous when viewed between crossed Nicol prisms, and are of course inflammable. Slides prepared from viscose or one of the cellulose acetates might prove very serviceable in this connection if obtainable.

It is useless to attempt microchemical work without a preliminary practical study of the reactions; illustrations in text-books often give a very inadequate idea of the actual appearance of the characteristic crystals under the microscope, and, moreover, some little experience is frequently required in order to obtain the reactions at all. Thus even such a very crystallisable and well-defined substance as cæsium alum, the formation of which serves as a reaction both for aluminium and for the sulphate radicle, only forms in well-defined characteristic octahedra within certain well-defined limits both of concentration and of acidity, and without a little practical experience of the reaction it would be quite easy to miss quite a large proportion of a sulphate. If the right conditions are not satisfied either no crystals appear, or they appear unduly slowly, or as ill-defined crystalline aggregates which only lead to confusion.

THE ALKALINE WATERS OF THE LONDON BASIN.

By JOHN C. THRESH, M.D., D.Sc.

Continued from Vol. I., page 394.

The table, shows, however, that whilst the carbonates and sulphates of sodium increase approximately in proportion to the decrease in the corresponding salts of magnesium and calcium, the amount of common salt seems to bear no relation to any of the other constituents. This is better brought out in Table III., which refers to a localised area which has recently had to be studied somewhat fully, viz., the Tendring Hundred, Mersea Island, and the Tollesbury districts. I have analyses of waters from about 50 deep wells in this area, and the salt varies from 23 parts to 180 parts (or probably more) per 100,000, and it will be noted that some of the waters containing least salt are derived from wells near tidal estuaries, whilst many of the waters containing much salt are miles inland. The analyses of certain of the waters, however, indicate that tidal water is gaining access. This is well marked in the analysis of the Manningtree waters, No. 2 on Table 3. The Geological Survey refers to wells at Ramsey, Pewit Island, Frinton and other places, which yielded brackish water and were apparently abandoned. Dr. Cook, Medical Officer of Health for the Tendring district, informs me that at Walton a well was bored and the water found to become more salt as the depth increased, the figures being:—

At 100 ft.	Salt per 100,000 parts of water	257 parts.
At 200 ft.	"	258 "
At 300 ft.	"	293 "
At 360 ft.	"	308 "

A well sunk at Clacton gave me the results No. 3 on Table III. The yield of water was trifling, and upon

continuous pumping the water became so brackish that it was abandoned. It will be noted that the water which rose naturally in the bore was comparatively soft and contained sodium carbonate and no more salt than the deep well-waters of Mid-Essex. I am sorry that I did not obtain a sample of the water after continuous pumping, but the engineer informed me that it was so salt that no analysis was necessary to show that it was too brackish for domestic use.

TABLE III.

Source.	1 to per cent. Sea Water.	2 Chalk, Manning- tree.	3 Chalk, Clacton.	4 Layer 568 ft.	5 Marney, 900 ft.	6 Mersea.
Calcium Carbonate ...	·8	23·5	5·3	1·4	6·3	5·5
Calcium Sulphate ...	13·3	—	—	—	—	—
Calcium Chloride ...	—	—	—	—	—	—
Magnesium Carbonate	—	6·5	4·2	·4	3·8	5·2
Magnesium Sulphate	21·9	7·2	—	—	—	—
Magnesium Chloride	36·7	1·8	—	—	—	—
Sodium Carbonate ...	—	—	22·0	30·1	29·2	32·5
Sodium Sulphate ...	—	—	16·1	12·7	12·4	22·0
Sodium Chloride ...	267·6	22·9	61·7	66·3	144·3	136·8
Sodium Nitrate	—	·2	2·6	·6	—	—
Silica, etc. ...	—	2·7	2·0	1·5	—	·6
Total ...	357·	64·8	114·5	122·	196·	203·5
Hardness ...	abt. 100°	45°	11°	2°	11°	12°

There is no doubt that in this area the water varies in character at different depths. The salt in the Walton water shows this as does also the analyses of waters taken from borings recently made at Layer Marney, Nos. 4 and 5 on Table III. The yield at 568 ft. was very limited under 200 gallons per hour, and the boring was continued to 900 ft. and blasts of dynamite used, but the yield of water was not materially increased and the proportion of salt increased to such an extent that the water was useless.

Layer Marney is so far from the sea that it appears difficult to ascribe this increase in the amount of salt to any direct influx of sea water, but my impression is that sea water or tidal water is gaining access to the chalk in the Thorpe-le-Soken area and at and near the chalk outcrop in the Stour Valley. The proof that these saline waters are derived from an admixture of sea water and chalk water is, I think, proved by the analysis of mixtures of chalk water and sea water after passing through a filtering medium which can remove the calcium and magnesium salts more or less completely, substituting sodium and potassium in their place. The mere proximity to the sea does not enable anyone to say whether a water will be salt or not, as a well near the coast may or may not contain an excessive amount of salt. For example, compare typical waters from Brightlingsea with those from Mersea Island and Tollesbury.

I have made several experiments with mixtures of sea water and chalk water to show the effect of the softening process which I shall describe presently, and the following Table (IV.) is designed to show how the various waters in the London Basin can be imitated by mixing chalk water with sea water and then submitting them to this peculiar treatment.

Varying proportions of chalk water and sea water were mixed, a portion reserved for analysis and the remainder filtered through Thanet sand of varying thickness and of varying activity so as to remove a portion or nearly the whole of the calcium and magnesium salts. It will be observed that the lime and magnesium salts have been more or less completely removed, and that the resulting filtrates are exactly of the type of the waters in the Tendring area, as exemplified by the Tollesbury sample.

TABLE IV.
SEA WATER AND CHALK WATER.

Source,	Untreated.	Treated.	Untreated.	Treated.	Untreated.	Treated.
Calcium Carbonate...	12·7	2·0	25·2	1·0	24·3	3·8
Calcium Sulphate ...	29·0	—	—	—	—	—
Calcium Chloride ...	1·0	—	—	—	—	—
Magnesium Carbonate	—	1·7	2·5	·5	3·4	·4
Magnesium Sulphate	—	—	12·3	—	8·9	—
Magnesium Chloride	10·3	—	6·6	—	—	—
Sodium Carbonate ...	—	9·0	—	31·8	—	29·2
Sodium Sulphate ...	—	30·3	—	16·3	—	15·6
Sodium Chloride ...	103·5	118·8	113·1	126·2	72·0	73·0
Sodium Nitrate ...	—	—	—	—	—	—
Silica, etc. ...	—	3·2	1·	2·2	—	2·0
Total ...	156·5	165·0	161·	178·	111·0	124·
Hardness ...	40°	4°	40°	1½°	33°	5°

It would be difficult to regulate the rapidity of filtration, or to vary the thickness of the filtering medium, so as to remove exactly the right proportion of the salts of calcium and magnesium, but, as we know that these can be removed to any desired extent, the effect of the filtration can be easily calculated.

TABLE V.

HALSTEAD CHALK WATER + 2 1/2 SEA WATER.

Source.			1 Untreated.	2 Treated.	3 Compare with Bramfree.	4 Treated.	5 Compare with Wiham.
Calcium Carbonate ...	...	...	27·3	5·3	5·3	2·8	2·8
Calcium Sulphate ...	...	...	1·8	—	—	—	—
Calcium Chloride ...	...	...	—	—	—	—	—
Magnesium Carbonate	...	...	—	5·5	5·5	1·4	1·2
Magnesium Sulphate	...	...	8·0	—	—	—	—
Magnesium Chloride	...	...	9·8	—	—	—	—
Sodium Carbonate ...	...	...	—	16·7	19·8	25·2	26·7
Sodium Sulphate ...	...	...	—	11·4	11·9	11·4	10·8
Sodium Chloride ...	...	...	63·3	75·2	67·2	75·2	78·3
Sodium Nitrate ...	...	...	·3	·3	·2	·2	·3
Silica, etc. ...	...	...	1·0	1·1	1·2	1·3	·4
Total	...	...	111·5	115·5	111·1	117·5	120·5
Hardness ...	...	...	—	12°	12°	5°	5°

Table V. shows how a mixture of 2 % of sea water with 98 % of chalk water from Halstead would be altered by filtration through different thicknesses.

Braintree is about halfway between Halstead and Witham. Assume that the water from the chalk at Halstead becomes mixed with 2 % of sea water on its way to Braintree, and at the same time is traversing the Thanet sands and becoming softened. Then the result at one stage would be the water (2), which, as will be seen, bears the closest possible resemblance to the Braintree water (3). Travelling onwards towards Witham the water would become still softer, more of the calcium and magnesium salts being removed, and at some point a water having the composition of No. 4 would result, and this, it will be noted, bears the closest resemblance to the Witham water No. 5.

TABLE VI.
CHLORINE AND BROMINE IN SEA WATER AND ESSEX
DEEP CHALK WATERS.

	Chlorine in 100,000 parts of Water.	Ratio of Bromine to Chlorine.
Sea Water, Clacton	1885	I to 274
" " Blackwater Estuary	1850	I to 328
" " " " " " " " " " " " " "	1850	I to 378
Tollesbury Deep-Well Water	75	I to 225
*Chelmsford " " 	35	I to 250
" " " 	35	I to 322
Malden " " 	50	I to 442
Tillingham " " 	76	I to 317
Barking " " 	324	I to 312

*Two separate determinations of each water showing variation in results due to difficulties in analysis.

By varying the source of the chalk water and the proportion of sea water, I think every water from the chalk and Thanet sands in the county of Essex and under London could be imitated.

Assuming that the salinity is due to sea water, then the bromides which exist in sea water should be capable of detection in the saline waters. This proved to be the case.

The Barking waters are very interesting (Table VII.). Away from the river (1) they resemble the chalk water of the Lee Valley partially altered by filtration through Thanet.

TABLE VII.
CHALK WATERS.

Source.	1 Bark- ing Town.	2 Bark- ing Creek, Well at.	3 Bark- ing Creek, Well at.	4 Thames. Grays. River.	5 Gra ys. Heavy Pump- ing. Chalk	6 No Pump- ing Well.
Calcium Carbonate ...	5·3	28·2	29·8	16·3	25·0	17·1
Calcium Sulphate ...	—	2·5	—	71·4	28·4	4·8
Calcium Chloride ...	—	—	—	—	—	—
Magnesium Carbonate	1·4	—	—	—	—	—
Magnesium Sulphate	—	7·4	13·1	129·5	8·8	1·6
Magnesium Chloride	—	18·6	9·9	154·8	24·6	1·7
Sodium Carbonate ...	14·9	—	—	—	—	—
Sodium Sulphate ...	9·9	—	—	—	—	—
Sodium Chloride ...	7·0	112·5	75·9	1411·6	140·4	2·6
Sodium Nitrate ...	—	—	—	—	—	—
Silica, etc. ...	·5	·8	1·3	70·4	15·8	4·2
Total ...	39·	170·	130·0	1854·	243·	32·
Hardness ...	7°	55°	50°	330°	78°	24°

sand, but near the river they consist of a mixture of this chalk-derived water and river water. Nos. 4 to 6 show the effect of the Thames water on the Grays wells when heavily pumped.

The proportion of bromides to chlorides is therefore much the same as in sea water, whether the saline water contains as much salt as the Barking water, or little salt like the Chelmsford water.

CORRESPONDENCE.

To the Editor of THE CHEMICAL WORLD.

SIR,—The world of popular science has recently feasted on "Sugar from Wood." A quite serious paper read before the Society of Arts on December 4th, dealt with the utilisation of wood waste (sawdust) by way of the Classen process (digestion at high temperatures, with SO_2 . Aq), and the employment of the product as a cattle food. But the daily Press with its inevitable "motif" has seized on particular aspects of the problems involved, and exaggerated statements, *ad captandum populum*, are in active circulation.

It is of course a matter of concern to us that misrepresentations of science in the Press are not only frequent, but usual; and it is a fair suggestion to responsible editors that matters of this order should be scrutinised and passed by competent critics, either of the permanent staff, or occasionally co-opted.

It is also for us to consider what measure of responsibility attaches to us, as workers and publicists, for the "sensations" which periodically flutter the reflective community; as, for instance, the "Synthetic Rubber" propaganda, and the speculative treatment of the potentialities of the chemist "Demon" in relation to life which was made to take the place of the nebulous sea serpent in the "silly season."

These matters both represent serious work and thought of the highest order, and it would be superfluous to labour proof of the statement, or to give particulars of the appreciative estimates of men of science of the labours involved, whether of authors or investigators. But the "public" is interested in products not processes; joy's soul to "it" is not in the doing, but in handling the proceeds of the thing done!

It is a mistake not to recognise this. The consequences of presenting the speculations of science in the ephemeral terms and false perspective of a newspaper article is to appear to court a public tribute to a nine days' living wonder, and thereafter a pauper funeral and hurried burial with the unconsecrated dead. The public has a short memory, correlated with its indiscriminating estimates of value, and it is for these reasons that "Synthetic Rubber," "Sugar from Wood," "The Origin of Life," "Standard Bread," "Sour Milk Regeneration," etc., having done their turn on the journalists' variety stage are supposed to connote permanently nothing more than contributions to the world's intellectual scrap-heap! We only call attention to these particular cases for their obvious connection with the World of Science. No further comment is necessary. *Verbum Sap.*

Yours faithfully,

VERITAS.

COMMERCIAL AND GENERAL NOTES.

Lead Poisoning in the United States.

In view of the investigations of the recently appointed committee on the question of lead poisoning in Great Britain, it is interesting to hear that the American industries show much worse conditions than our own. A detailed discussion on the influences of lead poisoning in the American industries has just been brought out by the officials of the Department of Commerce and Labour. From a review of this report, as made by the Department officials, it is disclosed, among other things, that in a study of lead poisoning in potteries, tile works and porcelain enamelled ware factories, Dr. A. Hamilton found that, compared with British potteries, American establishments with less than half of the workpeople show almost twice as many cases of lead poisoning. Even these figures, unfavourable as they are to American factories, do not tell the whole truth, for in the absence of legal requirements for the recording or reporting of cases of lead poisoning at the time of the investigation, it was impossible to make a complete census of the cases which had occurred during the last two years.

A Factory for the Manufacture of Alcohol from Henequin Waste.

For some years the Board of Agriculture of Yucatan and the planters of henequin have been endeavouring to utilise the waste portions of the plants after fibre extraction. It has been finally discovered that alcohol can be extracted from the waste and the trunks of the henequin plants after the removal of the leaves, and an experimental station was established on the Kanan plantation. This has proved very successful, and as a consequence the local board of agriculture (Cámara Agrícola de Yucatán) is forming a stock company, capitalised at \$12,500 U.S. currency, to exploit this new industry and establish the necessary installations at the Kanan plantation. It is hoped that the new industry will add largely to the already satisfactory income accruing to Yucatan from the henequin plant.

Enzymes of *Aspergillus Oryzæ*.

The researches of Kika (Wochenschrift fuer Brauerei) show that *Aspergillus oryzae* produces diastase, no matter what kind of nutrient medium is employed. As reported by Saito, however, the diastatic power is but feeble when ammonium chloride or sulphate is used as the source of nitrogen. The defective saccharifying power, however, is not due to the absence of diastase, but to the action of the free mineral acids in the solution on the diastase. Consequently, in presence of any compound that is capable of neutralising the free acids, the saccharification is just as good as when potassium nitrate or asparagin forms the source of nitrogen.

The injurious influence of acids on the diastase depends on the concentration of the latter, a quantity of acid that will cripple a weak solution of diastase being inert or even favourable, provided the enzyme solution be sufficiently strong. For this reason the diastatic power of cultures of *Aspergillus* is greater, without neutralisation, when the fungus is grown in a concentrated condition, even though

ammonium sulphate forms the source of nitrogen. The quantity of the enzyme is affected by the properties of the nutrient medium. The diastatic power fluctuates with the age of the organism, and especially so in the stage of conidial fructification.

Formalin as a Poison for Flies.

Professor R. I. Smith, entomologist to the Government of the U.S.A., strongly recommends the use of formalin as a poison for flies. The method he has found most successful is the use of formalin in milk, in the proportion of 1 oz. of the former to 1 pint of equal parts of milk and water. In this proportion the mixture attracts the insects better than when the formalin is used in sweetened water. Experiments in fly-infested rooms and stables have proved that the mixture is most effective. Being cheap as well it is a valuable means of destroying the dangerous insect pest.

The Determination of Arsenic.

The United States Bureau of Chemistry has issued a circular, No. 102, on the subject of "The Determination of Arsenic," which is prepared by Claude R. Smith, Assistant Chemist in the New York Food and Drug Inspection Laboratory.

The subjects covered in this discussion of the determination of arsenic are the determination of small amounts of arsenic by a modified Gutzeit method, the determination of large amounts, the preparation and treatment of samples for arsenic determination, and also the separation of arsenic from antimony and tin. In his introduction to the subject the author says that "the study of the determination of small amounts of arsenic was begun by the writer about three years ago in the examination of the purity of the seven coal-tar colours that are permitted for use by the United States Government. Since then the estimation of arsenic in shellac, glucose, calcium-acid phosphate, baking-powder, hops, gelatine and other products has been undertaken, and the experience gained from an aggregate of several thousand determinations made in the New York laboratory.

The methods recommended are concerned with the estimation of amounts of arsenic ranging from one micro-milligram to ten or more milligrams, and include particularly various modifications of the Sanger-Black-Gutzeit determination of arsenic, which seem to improve its accuracy and practicability, new methods for the measuring of the arsenic from comparatively large amounts of arsenic, and a new method for the quantitative separation and concentration. In attempting to secure experimental data to establish this point great difficulty was encountered in obtaining potassium antimonyl tartrate, which was to supply the antimony, free from arsenic. One of the samples of potassium antimonyl tartrate tested was a standard brand of analysed chemicals which purported to be arsenic-free. The test applied was evidently too rigid, for the arsenic amounted to one hundred times more than could be well handled by the modified Gutzeit method."

Improving the Quality of Plantation Rubber.

A recent issue of the *Times of Ceylon* contained an interesting paragraph regarding a demonstration given by Mr. H. A. Wickham, the "Father of Plantation Rubber," in which he produced hard fine Para from Ceylon latex. The product is said to equal Brazilian rubber. Mr. Wickham contends that the difference between Brazilian hard fine Para and plantation rubber is only a matter of treatment, and his demonstration on the estate has produced

very satisfactory results. The rubber has been turned out in the shape of blocks, and is believed equal in every respect to fine hard Para, consisting, as Mr. Wickham says, not of a curd or coagulation latex but of an amalgam of the whole latex with the preservative smoke. He adds that he found plantation latex if anything richer than that produced on the Amazon, and similarly treated ought to form a superior, not inferior rubber. Half a ton of this product is being sent to London in order to give manufacturers a chance to judge for themselves.

An Interesting Chemical Establishment in India.

The *Times of India* publishes an account of the decision of a firm of chemical manufacturers of Manchester, Messrs. H. N. Morris & Co., Ltd., to establish a plant in that country. It is proposed to manufacture Epsom salts, zinc chloride, Glauber's salts, magnesium chloride, superphosphates, etc. It is stated that this firm has acquired a large area at Matunga, where a factory is being built as rapidly as possible, in order to commence operations in April of next year. Many other chemicals will probably be manufactured later. The raw materials to be utilised are more or less abundant in India, and the undertaking seems, therefore, to have a fair chance of success.

Mercury in Surinam.

Some months ago it was rumoured, says the *Indische Mercur*, that cinnabar had been found at Marowije, which is confirmed by statements in *De West*. According to this paper samples of the ore have been deposited in the Surinaamsche Bank. They are remarkably heavy, heavier than gold quartz. The ore is of scarlet colour, and the crystal is recognised by its cleavage. The material is rich in quicksilver and has caused the formation in Holland of an exploitation syndicate for further search, under an option, on the land where the ore was found.

Uses for Minor Metals.

According to economic geologists, a fortune awaits the man who can invent a use for tellurium. This mineral, says the *Scientific American*, is one of the by-products of copper refinery and of plants working up gold telluride ores. At present it is thrown away, as it is no good to anybody. Only a few years ago tungsten was in the same position as tellurium is now. Then it was found to be highly useful in the manufacture of incandescent lamps and tool steel, till to-day it would seem probable that, with a cheaper supply, it will become one of our most important minor metals. Selenium is another substance which has just come into its own. Up to a year ago no commercially important use for selenium was known, although for some three or four years it was one of the ingredients entering into a secret process in the glass industry. It is now well known among scientists that selenium is an agent in colouring glass red, and in decolourising glass by the use of small amounts to neutralise the green of ferrous iron. A French scientist has also utilised it in an invention by which pictures may be transmitted by wire.

New Retort for Turpentine Extraction.

The foreman and another employee of the Dantzer Foundry and Machine Shops at Gulfport, U.S.A., have invented and patented a rotary retort for extracting turpentine, rosin and other products from pure wood. This machine, according to the Commissioner of Patents in Washington, is the best yet devised.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.

15919/12. DEUTSCHE GASGHÜHLICHT AKTIENGESellschaft (AUERGESELLSCHAFT), Berlin. **Thorium**. Dated under the International Convention, as 17 August, 1911.

Thorium is precipitated and separated from other rare earths by adding hypophosphoric acid or easily soluble salts thereof to an acid solution of the rare earths. (1 claim.)

24170/11. E. A. ASHCROFT, London. **Sulphide Ores**. 31 October, 1911.

The process of treating sulphide ores in accordance with this invention consists in utilising the chlorine produced in the electrolysis of a chloride of an alkali metal (for the simultaneous production of alkali compounds or metal) by treating therewith a metal sulphide ore suspended in, or mixed with a fused metal chloride for the production of metal chlorides and sulphur or sulphur compounds. (7 claims.)

24763/11. V. L. BEDIER, Washington, U.S.A. **Explosive**. 7 November, 1910.

An explosive in accordance with this invention consists of potassium chlorate, a crystalline carbohydrate, hard-wheat bolted flour, chrysophanic acid and a colouring agent. (4 claims.)

24905/11. H. W. LAKE, London. **Liquefiable Hydrocarbon Gases**. 8 November, 1911.

The process of manufacturing hydrocarbon gas in accordance with this invention, consists in evaporating water and heating a quantity of iron chips to a bright red heat in a common chamber and in passing the vapour together with hydrocarbons through the heated iron chips. (3 claims.)

25805/11. W. PHIRATUS, Stuttgart. **Caoutchouc Substitutes**. 18 March, 1911.

Caoutchouc substitutes or preparations suitable therefor are manufactured from gelatine or other colloids of animal or vegetable origin by treating the same at a suitable stage of their manufacture with suitable esters of the multivalent alcohols of the fatty acid series or of their derivatives; always excepting the chlorhydrines and acetone. (3 claims.)

25891/11. C. B. ELLIS, London. **Alkali Amide**. 20 November, 1911.

A process for the manufacture of alkali amide from alkali metal alloy and ammonia consists in exposing the alkali metal alloy in a finely divided state to the action of ammonia, or in leading the molten metal in a counter current against a stream of ammonia. (2 claims.)

26036/11. SPRENGSTOFFWERKE DR. R. NAHNSEN & CO., Aktiengesellschaft, Hamburg. **Monochlorhydrin**. 11 February, 1911.

Monochlorhydrin is prepared by treating glycerin with hydrochloric acid gas *in vacuo* and at such a temperature above 100° as will permit the monochlorhydrin to separate from the reaction mixture. (3 claims.)

978/12. A. VON WASSERMANN, Berlin, and E. WASSERMANN, Frankfurt-on-the-Main. **Seleniferous and Telluri-**

ferous Substances. Dated, under the International Convention, as 4 November, 1911.

A process for the preparation of seleniferous and telluriferous coloured substances in accordance with this invention is characterised by the feature that dyestuffs of the phthalein series or their derivatives, especially the halogenised or alkylated derivatives, are allowed to react with soluble selenocyanide or tellurocyanide salts. (2 claims.)

8400/12. ISABELLEN-HÜTTE, G. m. b. H., Dillenberg. **Treating Manganese Ores**. Dated, under the International Convention, as 7 April, 1911.

Metallic manganese is extracted from its ores by calcining a portion of the manganese ore at a red heat, adding a suitable proportion of uncalcined ore, and then subjecting the mixture to the action of a carbonaceous reducing agent. (1 claim.)

3350/12. THE FIRM ELECTROCHEMISCHE WERKE, G. m. b. H., Berlin. **Pyrophorus Metal Alloys**. 28 March, 1911.

Pyrophorous metal alloys consist, according to this invention, of one or more of the rare earth metals in the pure state with an addition of one or more of the metals zinc, cadmium, tin, or lead. (3 claims.)

14009/12. H. BÜCHLER, Zurich. **Distilling Mineral Oils**. 16 June, 1911.

The process of distilling mineral oil by steam is characterised by the fact that the steam is generated direct in the oil by the heat of the latter, small quantities of water being introduced into the oil, which is heated above 100°, so that the water is evaporated and prevented from collecting at the bottom. (1 claim.)

15658/12. FARBERWERKE VORMALS MEISTER, LUCIUS AND BRÜNING, Hoechst a-Main. **Methylsulphites of Amino-Antipyrine**. 20 July, 1911.

Methylsulphites of amino-antipyrine and derivatives thereof substituted in the phenyl nucleus are manufactured by causing alkali or ammonium formaldehyde-bisulphite to act at a raised temperature upon amino-antipyrine or a derivate thereof substituted in the phenyl nucleus. (2 claims.)

21728/12. FARBERWERKE VORMALS MEISTER, LUCIUS AND BRÜNING, Hoechst a-Main. **Hexamethylenetetramine**. 25 September, 1911.

Camphorates of hexamethylenetetramine are manufactured by dissolving molecular proportions of hexamethylenetetramine and camphoric acid in an indifferent solvent and allowing the product to crystallise. (2 claims.)

21729/12. FARBERWERKE VORMALS MEISTER, LUCIUS AND BRÜNING, Hoechst a-Main. **Red Dyestuff**. 6 December, 1911.

A red wool dyestuff fast to milling, is manufactured by causing the tetrazo-compound of metatolidine to act upon two molecular proportions of 2-naphthol-6-sulphonic acid. (2 claims.)



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OXFORD UNIVERSITY LABORATORY.

THE recent election of Professor W. H. Perkin to the Chair of Chemistry at Oxford, carries with it far more than is explicitly stated in the published announcement. Simultaneously with the appointment of the foremost and most active organic chemist in the country to its Professoriate, the University of Oxford has taken other decisive and well-considered steps for the purpose of definitely placing its chemical department in advance of most of the modern chemical schools, so far as concerns both educational work and original investigation in our science. The necessary arrangements have been made in Oxford for securing a site for a new laboratory, for financing the building, equipment and upkeep of the same, for reorganising the existing University laboratory, and for maintaining a liberal outflow of research work; whilst these developments have been already instituted it is understood that others are in contemplation, and that a second Chair in Chemistry will be founded in the near future. The revolution which is taking place so quietly in Oxford is precisely paralleled by that instituted in Cambridge about four years ago; no one can realise what a development in teaching and research in our subject has occurred in the University of Cambridge during the past few years, without actually inspecting the chemical laboratories which were described by Dr. W. J. Sell in this Journal some months ago.

We doubt whether the general body of chemists quite realises the extent to which modern chemistry has established its position at Cambridge. Since the institution of the new *régime* four years ago about 150 original communications have been published from the chemical laboratory of that university; no other institution in this country, and possibly no other on the Continent, has turned out such a quantity of original work in such highly differentiated branches of our science. At the same time, the number of undergraduates and post-graduate students working at chemistry in the chemical laboratories of Cambridge University has more than doubled.

That similar success will come to Oxford can hardly be doubted. With Professor Perkin at Oxford, and Professor Pope at Cambridge, it is evident that the older universities have adopted a modern programme, and that the influence of the changes which are taking place cannot fail to be reflected on the general educational system of this country.

The older universities hold a unique place in the affections of the English people, and this feeling would, with difficulty, be transferred to the more modern institutions, excellent though many of these are. That the country has been waiting for some such change as that indicated goes without saying. The fact that this has been realised by Oxford is, therefore, welcome news. This development is, no doubt, to a great degree due to the unqualified success of recent progress at Cambridge.

It is difficult to think of any step which could so definitely bring before the intellectual public of England the demand for a more thorough system of scientific teaching than this recent action of the older universities. Nor is it easy to imagine more suitable surroundings for the furtherance of modern research than at Oxford and Cambridge. The traditional method of these Universities, when combined with modern practice, should sweep all before it, and materially influence progress.

There can be little doubt but that such changes as these will add dignity to science, and act at the same time as a steadying influence and a balance to modern thought. All this is to the good. The change is a welcome one, and marks a serious and well-thought-out advance on thoroughly English lines. This country is to be congratulated on the step taken at Oxford, and in the great progress already made at Cambridge. An advance all down the line is naturally to be expected. This will be all the more useful from the fact that it has come at a time when the general trend of thought in this country is fully prepared for it.

Whilst these rapid changes are being effectuated in the older universities, it is interesting to consider

the position of chemical teaching and research in London and the provinces, especially in view of the fact that a Royal Commission has been deliberating for several years upon possible methods for abolishing the scandalous position of the University of London, and for establishing in the greatest and wealthiest city in the world a university comparable in its influence upon the national efficiency to that enjoyed by any of the smaller German universities. During recent years it has been discovered that social and political success are within the reach of any wealthy person who is prepared, without himself possessing any particular learning in, or mastery over any specific branch of natural knowledge, to devote his leisure to attendance upon the committees and councils of educational institutions. A glance at the lists of members of the supreme governing bodies of most of the modern British universities will show that men of the type suggested are frequently in the majority; their effect upon scientific education and progress is a disastrous one, and without pursuing the topic further, we may extend our congratulations to the parent Universities of Oxford and Cambridge on the fact that they remain autonomous, that no person who is not an expert in education or research gains a position upon any of their senior governing bodies, and that changes, although perhaps slow, are instituted as the result of well-considered and matured reflection.

Teaching of Science in Schools.

Sir Archibald Geikie's address to the Public School Science Masters Association is of distinct value in the fact that it indicates the changes which have taken place in the teaching of science in the Public Schools, during the last sixty years. At that early time he described the position in the following words:—

"Here and there might be found an enlightened headmaster or other teacher who, impressed with the profound interest and the great educational value of the natural sciences, contrived to find time amid his other duties to discourse with his pupils on that subject. He might perform a few simple experiments illustrative of some of the fundamental principles of physics or chemistry, or disclose to their young eyes some of the marvels which they might discover for themselves among the plants and animals of the countryside. Such broad-minded instructors, however, were rare and far ahead of their time. There were then no special science teachers, no school laboratories, no proper school museums. The range of instruction in the public schools still lay within literary lines, pretty much as it had existed for centuries. Boys left school, for the most part profoundly ignorant of Nature, save what they gained from their own observation, reading or reflection."

Even at the higher centres of education things were in much the same position.

"At the universities they fared little better. Chairs for the cultivation of various branches of science had, indeed, been founded, but the duties of the professors were usually considered to consist in the delivery of lectures

which were sometimes dull enough, and, not required in reading for degrees, would attract but scanty audiences. Buckland at Oxford and Sedgwick at Cambridge gathered round them enthusiastic bodies of listeners, but the laboratory work and experimental demonstrations, now admitted to be so essential, had hardly begun to be instituted in the universities. Kelvin's famous physical laboratory was only started about 1850, and that of Tait in Edinburgh some years later."

Sir Archibald Geikie insists, and rightly so, that in a general system of education, the literary side, from its manifold human interest, must in its widest sense remain predominant, and that no amount of training in science can compensate for an inadequate training in literature. The presence of general culture is a *sine quâ non* for the scientific man. Sir William Tilden emphasised this in unmistakable terms in the discussion which followed. At the same time men have come to comprehend that certain faculties of the human mind are best developed by the study of science.

"Every boy at a public school should be given the opportunity of obtaining a broad, general idea of the scope and bearings of natural science and of having his apprehension stirred with regard to the manifold interest and charm of Nature. These ends required to be supplemented by practical work by the pupils, and they must also learn the fundamental elements of biology and geology, studying not only with the teacher in the classroom but with specimens of plants and animals in the laboratory or museum, and where possible in the field. To secure this indispensable minimum of science teaching every public school of the first order must be possessed of laboratories sufficient in size for the convenient accommodation of the pupils and furnished with all the necessary equipment for practical work. There ought to be a laboratory for physics, another for chemistry, and, if possible, another for biological studies. In conclusion, the masters should never lose sight of the possibility that among the pupils might be the Kelvins, the Rayleighs, the Darwins, or the Hookers of the time to come."

Compulsory Greek.

The recent suggestion made by the Head-Masters in Conference that Oxford shall no longer insist upon compulsory Greek, will come before the authorities with added force at a time when the university is making such definite plans for developments in modern science. It may be noticed as a sign of grace in this direction, that Dr. Macan of University College, Oxford, when recently addressing the Modern Language Association, remarked that "There is more virtue in ploughing through a good translation of a Greek work, than in being 'ploughed' many times in the original for 'smalls.'"

If it is accepted in principle, that the essential features of Greek thought can be realised in translations, the position is greatly simplified. Beyond this Dr. Macan relies upon voluntary converts, considering, like a true teacher, that each subject should be presented on its merits. He would leave such subjects to those who care, rather than drive the main herd over the educational cliff.

A LETTER FROM SIR HUMPHRY DAVY.

Communicated by SIR WILLIAM A. TILDEN, D.Sc., F.R.S.

THREE letters in the handwriting of Sir Humphry Davy have recently come into my possession. Two of these are addressed to Professor W. T. Brande, who, in 1813, succeeded Davy as Professor of Chemistry in the Royal Institution. These letters were written during Davy's travels on the Continent in 1818. The first, dated June 26th, is from Vienna, and conveys Davy's congratulations to Brande on his approaching marriage, and mentions Trieste as the next place at which he hopes to receive letters. The second letter contains matters of so much interest that it will be read with pleasure by those who care for a voice from the past. As supplying

a few facts of biographical importance it is also worthy of publication, for in John Davy's well-known life of his famous brother, he says (Vol. II., p. 99): "I cannot find any notes preserved of this journey."

The letter, with the address, covers the four sides of a quarto sheet of letter paper

folded and sealed with wax in the fashion of those days, which were long before the introduction and use of "envelopes." The address, which bears Davy's autograph, and the letter are given.

Perhaps it may be well to recall the course of the journey taken by Sir Humphry, who was accompanied by Lady Davy. Passing through Flanders, they ascended the Rhine, crossed Germany to Ratisbon, and passing down the Danube reached Vienna about June 13th. The journey through Austrian territory is indicated in the letter. After visiting Venice they made their way over the Apennines to Rome, and afterwards to Naples, where Davy began experiments on the unrolling of the Herculaneum papyri.

Early in the summer of 1819 he made his way back to his favourite haunts in Southern Austria, for fishing and shooting. The autumn he passed at the baths of Lucca, returning to Rome and Naples in the winter. The following spring the travellers journeyed slowly homewards and reached England on June 20th, 1820.

IDRIA,
Augt 23 1818

MY DEAR SIR

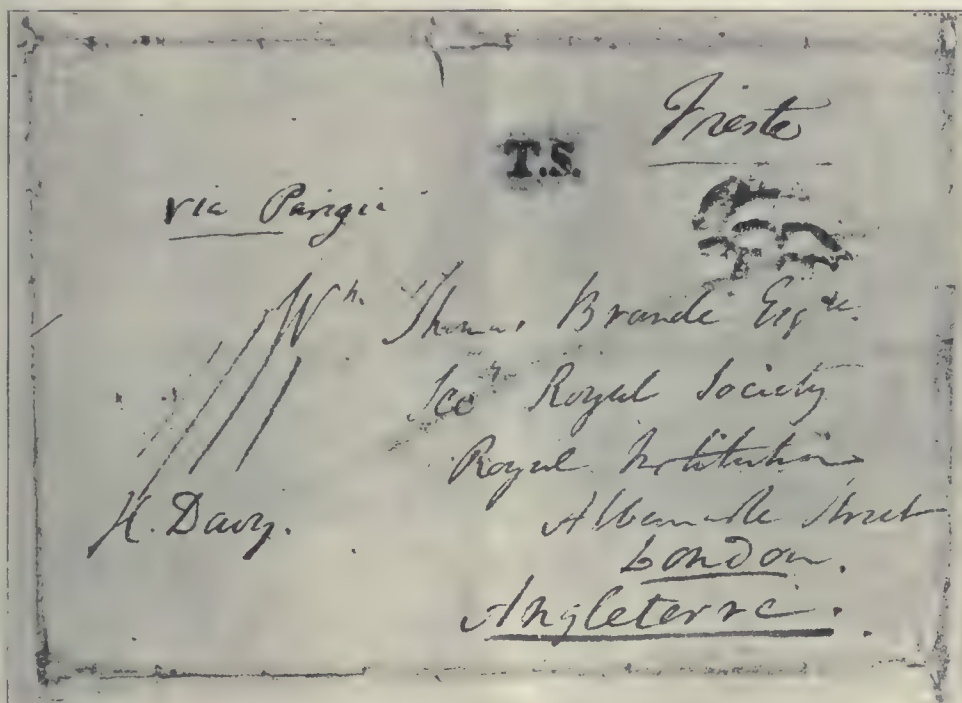
I hope this letter will not arrive before you are not only Benedictus but Beatus. For if this word

can at all apply to man in this his mortal state it is at such a time and in such circumstances.

Since I wrote to you at Vienna we have made a very long journey. I have visited the most interesting parts of Hungary, Styria, Saltzburg, and Carinthia and have seen some mountain scenery

quite as worthy of admiration as any I ever saw in the Swiss Alps. I have lived amongst the mountaineers purer and more uncorrupted than even the Swiss. We have had delightful weather and have had full enjoyments of a summer fine—but not sultry, in districts where without fine weather there could have been but little pleasure.

I will not write to you a geological letter or describe to you the great calcareous mountain chain that runs from Kermond in Hungary to Berchtesgaden in Bavaria and to the centre of Carniola with its belts of Breccia, and its intersections of Shist and its central column of Granite—I will not tire you with a page that might claim a place in the transactions of the plumb pudding stone Society ;



ADDRESS WITH SIR HUMPHRY DAVY'S AUTOGRAPH.

but I will give you a line on the *quicksilver mines* which I came here to see. The formation is in Bituminous Shist which sometimes emits inflammable air and which alternates with limestone like the Derbyshire. I have this day been down 1,120 feet and returned without being salivated. I pity the poor workmen who all lose their teeth in a very short time. The veins of cinnabar are very beautiful and one I saw nearly a foot in thickness. My Wife went down with me and visited the whole mine which is rather a feat to be talked of for a lady.—I found a good deal of inflammable air Carb: Hyd: in the great salt mine at Halstadt. The salt is like the quicksilver here in Bituminous shist.—I taught them the use of the lamp, which notwithstanding the science of their imperial proprietor they were still unacquainted with. A good many men had been burnt a few months ago. The inflammable air is found in largest quantities where the *blue* salt is. I have been again searching in vain for the cause of this extraordinary colour.

I sent in a letter to Mr. Hatchett a little of Professor West's new metal Sirium. I doubt its being a simple substance. Perhaps you will try a few expts. upon it—I believe I mentioned to you in my last letter Count Stadion's *Oxychloric acid*—a very curious substance, very like sulphuric acid and contains much more oxygine than Gay-Lussac's acid.

I have used detonating powder for Riviere's gun made with the *oxychlorate* of potassa to use Stadion's name and it answers perfectly.

I am now in the *Proteus Country* and I hope to send Sir Everard some alive. I go to the caverns where they are found the day after to-morrow.

I have seen nothing and heard nothing from England for two months. With every kind wish for your happiness and that of her most dear to you, in which my Wife joins me.

I am My dear Sir

very sincerely yours
H. DAVY.

Pray address to me *Rome*. We shall probably be there by the middle of Octr. on our way to Naples.

The following explanatory notes may be of service to the reader: Mr. Brande married in 1818 the youngest daughter of Charles Hatchett, F.R.S., then connected with the Mint. Brande himself became, in 1825, keeper of the dies at the Mint, and in 1852 he was appointed superintendent of the coining department. In the same year he resigned the active duties of Professor in the Royal Institution, where he had been associated for some twenty-five years with Faraday. Brande died in 1866 in the seventy-ninth year of his age.

The blue colour found in the rock salt at Hallstadt, referred to by Davy, occurs in salt from other places. The stains are of deep indigo-blue colour and transparent. The problem is one which remains unsettled down to the present day. An interesting paper by Ernst Erdmann on the occurrence of Helium in the gases from German salt deposits (*Ber.* 1910, 43, 777) contains the suggestion

that the blue colour is produced by the action of radium radiations on sodium chloride. If this turns out to be the true explanation it is not surprising that Davy should have failed to discover the cause.

The safety lamp was invented in 1815 and in a few months became generally known.

With regard to the supposed new metal "sirium" announced by Professor West, who appears to have lived at Graz, Davy's request to Brande to try a few experiments upon it led to a complete analysis by Faraday. An account of his examination of the small quantity, $\frac{1}{10}$ grain placed in his hands, is contained in the *Journal of Science and the Arts*, 1819, 6, art. xv., which was, until 1831, the *Journal of the Royal Institution*. Davy's suspicions were confirmed by Faraday's experiments. He found sirium to consist of sulphur, iron, nickel, and arsenic. As to the author of this "discovery" no information is now available.

Stadion's oxychloric acid is perchloric acid (*Gilbert's Annalen*, 1816, 197 and 339; *Annales Chim.*, 1818, 406), the chemical history of which was completed much later by Serullas (*Annales Chim.*, 1830, 270; and 1831, 294, 297, and 323), Roscoe (*Proc. R. Soc.* 1860—1862, 493) and others.

The "proteus country," mentioned toward the end of the letter, is in Carniola and Carinthia where the subterranean waters occurring in some of the caves of that district are inhabited by the curious amphibian the *proteus anguinus*, which seems to have interested Davy very much. One of the divisions of his "Consolations in Travel" is headed "The Proteus or Immortality."

Of course, the "Sir Everard" mentioned in the letter was Sir Everard Home (1756—1832), famous in his day as an anatomist, and first president of the Royal College of Surgeons (1821).

Determination of Water.—Messrs. Huntly and Coste have drawn attention before the Society of Chemical Industry to the frequent importance of an accurate determination of water in commercial products, and discussed the methods for the determination of water in various substances.

A. Direct Methods.—(1) Water driven off by ignition, condensed in part of ignition tube and weighed directly (Penfold). (2) Substance heated in a current of dry gas, or in a vacuum, water vapour collected in calcium chloride or sulphuric acid and weighed. (3) Substance mixed with an excess of a volatile non-miscible liquid, such as xylene, distilled, and the water measured under the hydrocarbon layer, with or without corrections for the mutual solubilities of the water and liquid used for its removal. (4) The material directly heated to 130° C. by a vapour jacket (high pressure steam), the steam given off condensed and measured. **B. Gasometric Methods.**—(5) The substance is mixed with calcium carbide; acetylene measured. (6) The substance is mixed with magnesium methyl halide in presence of a suitable dry solvent; methane measured. (7) The substance is treated with sodium; hydrogen measured. **C. Indirect Methods.**—(8) Determination of the loss of weight by heating to a definite or indefinite temperature; the usual method. (9) Prolonged exposure in a vacuum in presence of strong sulphuric acid, either at ordinary or at higher temperature.

WANTED—CHEAP ANTISEPTICS FOR USE IN HORTICULTURE AND AGRICULTURE.

By E. J. RUSSELL, D.Sc. (Lond.), Director of Rothamsted Experiment Station, Harpenden.

RECENT investigations made at the Rothamsted Experiment Station have shown that antiseptic substances may, under proper conditions, considerably increase the productiveness of soils, and there seems to be a prospect that large amounts could be usefully employed in horticulture, and if the price fell low enough, in certain branches of agriculture also.

The function of the antiseptic is to simplify somewhat the micro-organic population of the soil. A soil kept in a glass-house during a whole season, well watered, manured, and at a temperature distinctly above that normally obtaining outside, soon becomes inhabited by a great and various crowd of organisms. Especially is this true of commercial houses run at a high pitch to obtain maximum crops and subject to invasion by organisms from remote quarters of the globe. Growers of cucumbers, for example, who are perhaps the most intense cultivators in the country, buy quantities of stable manure and other refuse from London to fertilise their borders. This often contains all kinds of imported material—banana skins, orange peel and the innumerable trifles rejected by the city—many of which are capable of carrying spores from their country of origin. Once any of these undesirable aliens get introduced it spreads rapidly, for the conditions of the industry rather favour a transfer of pests from one house to another.

In consequence, the soil used for cucumber growing is thrown away at the end of the year and its valuable manurial residues sacrificed. A new lot is brought in, often at considerable expense, which is justified only by the consideration that the new soil is free from many of the disease organisms. In the picturesque language of the practical man the old soil is "sick" and is therefore rejected.

A second factor in soil sickness lies in the lowered efficiency of the micro-organisms in producing ammonia and nitrates. This has been traced to the abnormal development, under the circumstances of glass-house cultivation, of groups of organisms detrimental to the ammonia-producing bacteria.

The horticulturalist cannot afford to deal with a wholly sterilised soil free from all micro-organisms. The manures that he uses are not, as a rule, plant foods, but have to undergo decomposition and hydrolysis before they are reduced to compounds sufficiently simple to be taken up by plants. Of course he could grow his plants with the aid of sodium nitrate or ammonium sulphate alone, but this course, although possible, is not as convenient in practice as the addition of more complex compounds which undergo bacterial decomposition in the soil.

Fortunately the food-making organisms are on the whole less easily killed than the harmful varieties, and a certain degree of soil purification can therefore be effected by treatment with antiseptics or by heating to a temperature somewhat below 100° C.

Such treatment is commonly followed by an increased amount of plant growth and a healthier plant growth; bacteriological investigations show also that the numbers of bacteria have increased, and chemical analysis shows a marked increase in the rate of production of ammonia in the soil.

It is not our present purpose to discuss the scientific

problems involved but to direct attention to the cultural experiments. "Sick" soils from several large nurseries were treated with various antiseptics or by heat and then sown with crops; the untreated soils gave poor, diseased crops, while the treated soils gave larger and healthy crops. Large scale experiments have shown that the treatment is perfectly feasible for the practical man, but they have brought out several difficulties which, however, ought not to be beyond the power of the chemist to overcome.

When a "sick" soil is heated by steam to 98° it entirely regains its original productiveness—in fact it commonly does more because of the decomposition that has taken place. Treatment with antiseptics has so far not proved so effective. In testing the effect of various antiseptics we therefore have a definite and hitherto unattained standard to aim at. The general conclusion of our work up



FIG. 1.—TOMATO PLANTS GROWING IN SOILS TREATED WITH SMALL QUANTITIES OF ANTISEPTICS.

U = Untreated soil. T = Soil treated with toluene. Ph. = Soil treated with phenol. Py = Soil treated with pyridene. The soils were initially all alike; the plants were sown on the same day, and all treated alike. The antiseptics caused very considerable crop increases.

to the present time is to place the antiseptics in the following order of effectiveness :—

Class I. (the best antiseptic although not as good as steam).—Formaldehyde, pyridene, collidene and lutidene (*i.e.*, the fraction containing the higher bases).

Class II. (less effective).—Benzene, calcium sulphide, carbolic acid, cresylic acid, "light solvent naphtha," heavy solvent naphtha (*i.e.*, homologues of benzene), petrol, toluene.

Class III. (least effective).—Naphthalene, and certain derivatives obtained during its isolation.

As nearly as possible this is the absolute effectiveness, all subsidiary questions such as difficulty of application or distribution in the soil being obviated. The order in the various classes is alphabetical only, the experiments hardly being numerous enough to justify closer differentiation.

The antiseptics in the first class proved very useful. They killed the disease organisms—the eelworms (*Heterodera*), the damping-off fungus (*Pythium*), etc.—and they conditioned a satisfactory increase of bacterial numbers and of plant food.

The antiseptics in the second class were not so good in either direction and consequently gave less increase in crop.

There is no short and easy way of ascertaining the absolute effectiveness of an antiseptic. Our experiments

have invariably consisted in five series. Part of the soil is treated with 0.1% of antiseptic, part is heated for an hour to 95°–100° C., while the remainder is left untreated, and then :—

(1) Chemical analyses are made at periodical intervals extending over a month, to ascertain the rate at which ammonia and nitrates accumulate in the treated and untreated soils.

(2) At the same time bacteriological counts are made by the gelatine plate method to ascertain the rate of development of bacteria.

(3) Some of each lot of soil is inoculated into test tubes containing sterilised hay infusion, and after six days' incubation drops of the infusion are examined under the low power of the microscope for protozoa. If these organisms are killed by the treatment, it commonly happens that other harmful organisms are killed also.

(4) Seeds are sown in the soils and the young plants are carefully watched to observe the development of "damping-off," root knots, or other diseases.

(5) Plants are grown right through to fruiting, and the produce weighed.

The results of all the series are usually concordant, but it is not safe to dispense with any of the five, and we should view with suspicion any results so obtained. For preliminary sorting out (1), (2) and (3) give useful results in a short time and without requiring any special apparatus. But for final examination of an antiseptic all five are needed. It is essential to the proper carrying out of the experiments that the treated and untreated soils should be stored under similar conditions of moisture, temperature and reaction, and this can most conveniently be accomplished by allowing the excess of antiseptic to evaporate as far as it will, then making up the soils to uniform moistness, and finally putting up 800 gr. lots in clean litre bottles and plugging with sterilised cotton wool.

The absolute effectiveness of an antiseptic having been ascertained in comparison with one or two of the substances in the list just given, the next step is to determine the ease of

distribution in the soil. Like other colloids, soil has the remarkable power of withdrawing many dissolved substances from their solutions. It is therefore unsafe to argue that an antiseptic can be mixed with the soil simply because some gallons of its solution are easily watered on to the surface. Some of the antiseptics in the second class

(*e.g.*, carbolic and cresylic acids) are fairly readily abstracted in this manner, so that if a solution is poured on to a layer of soil 3 ins. in thickness (*e.g.*, contained in a Buchner funnel), the percolating water may be practically free from the antiseptic and the bottom layer of soil remains unaffected. From this disadvantage the vapours (formaldehyde, carbon disulphide, etc.) are free, but if they happen to be only sparingly soluble in water, they do not readily penetrate. Calcium sulphide also does not appear to suffer in this way. All substances are not equally affected, and some soluble materials will pass fairly readily into the soil. It is not necessary that the material should be wholly unabsorbed; the soil is mixed up to a considerable extent by the cultivation processes and a certain amount of distribution is thereby effected. But it is undesirable that absorption should be too complete, or the distribution becomes too local for the best results to be obtained.

A further important point is that the antiseptic must disappear from the soil after its work is done. This may come about in several ways. The low boiling substances simply evaporate. Calcium sul-



FIG. 2.—EFFECT OF SMALL QUANTITIES OF ANTISEPTICS ON THE SOIL.

U = Untreated soil. T = Soil treated with toluene, the effect being much less than in Fig. 1. Th = Soil treated with thiophen, the effect being very marked. ND = Soil treated with a residue obtained during the purification of naphthalene.

phide and bleaching powder decompose, leaving among their residual products a certain amount of valuable calcium carbonate. Carbolic acid, cresylic acid, and apparently other allied compounds are slowly oxidised by bacteria—a wholly remarkable change which deserves fuller investigation. Pyridene also is decomposed. Only an actual experiment avails to determine whether the antiseptic persists in the soil long enough to injure the young plant.

As only cheap substances are likely to be used, it is clear that some waste product is indicated. There must be many such products available. Solids would no doubt be most convenient, but liquids that are soluble or miscible with water, or could be made so by suitable admixtures, would also serve the purpose. Nitrogen compounds would possess an added advantage that they may decompose to yield plant food. Experiments indicate,

however, that some degree of standardisation is necessary and that the effect of the separate constituents of the mixture should be known. Thus it was found that samples of commercial toluene, which appeared to be fairly similar, differed pretty considerably in action. Later work showed that thiophen was a very potent agent, and left no doubt that variations in the amount of this impurity had caused the discrepancies observed. And further, the grower would probably not hesitate to put in a claim for compensation if any product supplied to him had done actual damage.

These are the difficulties the works chemist would be called on to deal with; that they are not insuperable is shown by the action of several enterprising firms in putting out soil antiseptics. There seems little doubt that, given suitable antiseptics, the chemical treatment of soils is likely to develop considerably.

RECENT PROGRESS IN THE CHEMISTRY OF THE PROTEINS.

By E. FRANKLAND ARMSTRONG, D.Sc., Ph.D., F.C.G.I.

A MOMENT has perhaps arrived when it is opportune to take stock of the progress in protein chemistry, a progress which has been little short of amazing when it is considered how little was known of the proteins at the beginning of this century. It will be remembered that the attack on their constitution was begun by Fischer, by the systematic study of the individual amino acids and their volatile esters, all of which have now been prepared synthetically and all but three resolved into their optically active isomerides. The proteins were hydrolysed, the mixture of products esterified and the esters of the amino acids separated in part by fractional distillation. A somewhat laborious series of operations, which has in course of time been improved in every direction, led to the separation of the component amino acids. New constituents of the protein molecule have been from time to time added to the list, until to-day there are seventeen such known. All sorts of proteins have been investigated by this method, mainly by Abderhalden and his school, or by Osborne, who has concerned himself particularly with the vegetable proteins. At first the proportion of the total protein represented by the amino acids isolated did not amount to one half, but it has been continually increased, and latterly the systematic researches of Abderhalden and of Osborne, on the probable losses which take place during the isolation of the amino acids, have made it probable that the protein molecule is composed entirely of the units which are already known.

Parallel with this analytical attack on the problem equal progress has been made from the opposite direction, that of synthesis. Fischer showed

first how to couple two amino acids, and subsequently developed methods of such excellence that the coupling of any number of amino acids in any desired order is to-day only a question of time and money. These coupled compounds—the polypeptides—soon begin to approach the peptones in their properties as the number of units in them increases, but what is of greater interest is the fact that when hydrolysis of a protein is effected by means of enzymes and arrested at an incomplete stage, it is possible to isolate such polypeptides among the simpler products of hydrolysis. This affords proof that the breakdown takes place in stages and that the amino acids are really linked together in the proteins in the same manner as in the synthetic polypeptides.

The synthetic polypeptides afford material on which the action of enzymes may be studied, and they serve also as test materials for investigating the chemical and physical properties of the proteins. One advantage they usually possess is their optical activity which enables the course of their hydrolysis to be followed quantitatively. This is a fact of no small importance when dealing with material where the products of change are difficult to distinguish analytically from the original substance.

Even with only three different amino acids as units, six distinct tripeptides are possible, differing in the order in which these units are arranged. All six tripeptides derived from glycine, d-alanine and l-leucine have been synthesised quite recently by Abderhalden and Fodor, who have carefully determined their physical and chemical properties. The differences are very small, so much so that

it would be well nigh impossible to separate them in admixture with one another.

Greater variety is, however, shown in their physiological behaviour. Abderhalden and Fodor made use of two types of enzyme—the one “activated” pancreatic juice, the other cell ferments such

Leucylalanylglycine, for example, is hydrolysed by pancreatic juice to leucylalanine and glycine, whereas yeast juice converts it into leucine and alanylglycine.

The differences are both striking and significant, and it will be interesting to study the behaviour

Tripeptide.	Melting Point.	Optical Rotation [α] _D ²⁰ .	Products of Hydrolysis by	
			Intracellular Enzymes.	Pancreatic Juice.
Glycyl-d-alanyl-l-leucine	239°	— 89·8°	Glycine + d-alanyl-l-leucine	?
Glycyl-i-leucyl-d-alanine	235°	— 59°	Glycine + l-leucyl-d-alanine	?
d-Alanyl-glycyl-l-leucine	243°	— 11·2°	d-alanine + glycyl-l-leucine	d-alanyl-glycine + l-leucine
d-Alanyl-l-leucyl-glycine	246°	— 30·4°	d-alanine + l-leucyl-glycine	d-alanine + l-leucyl-glycine
l-Leucyl-d-alanyl-glycine	252°	— 17·3°	l-leucine + d-alanyl-glycine	l-leucyl-d-alanine + glycine
l-Leucyl-glycyl-d-alanine	249°	+ 20·3°	l-leucine + glycyl-d-alanine	l-leucyl-glycine + d-alanine.

as extract of dried yeast or expressed juice from the liver or the pancreas. In several instances these two types of enzyme give entirely different results, acting, as it were, from the opposite end of the molecule. Analogous behaviour is of course known in the case of the trisaccharides, but it is particularly interesting to encounter it among the polypeptides.

of other peptides in this respect. One result is clear—the tripeptide will enable a distinction to be made between pancreatic juice and the so-called intracellular enzymes.

The six polypeptides, their physical properties and physiological behaviour, are reproduced in the table.

NOTES OF MEETINGS.

CHEMICAL SOCIETY.

February 6th and 20th, at 8.30 p.m. Ordinary Meetings.

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SOCIETY OF PUBLIC ANALYSTS.

February 5th, at 8 p.m. Annual General and Ordinary Meeting.

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SOCIETY OF CHEMICAL INDUSTRY.

LONDON SECTION:—February 3rd, at 8 p.m., “Paints,” by H. E. Armstrong and C. A. Klein.

LIVERPOOL SECTION:—February 12th, Dr. J. Harger, “Chemistry Applied to Coal-Mining.”

MANCHESTER SECTION:—February 7th, at Manchester University, Prof. H. B. Dixon, F.R.S., “Researches on Explosions in Mines.”

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SOCIETY OF ARTS.

February 3rd, Third Cantor Lecture on “Liquid Fuel,” will be delivered by Professor Vivian B. Lewes, at 8 o'clock.

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THE ROYAL INSTITUTION.

February 6th, Professor B. Hopkinson, “Recent Research on the Gas Engine,” at 3 o'clock.

February 8th, 15th, and 22nd, Professor Sir J. J.

Thomson, O.M., F.R.S., “The Properties and Constitution of the Atom,” at 3 o'clock.

February 21st, Mr. Spencer U. Pickering, M.A., F.R.S., “Horticultural Investigation at the Woburn Experimental Fruit Farm,” at 9 o'clock.

February 28th, Professor the Hon. R. J. Strutt, M.A., F.R.S., “Active Nitrogen,” at 9 o'clock.

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INSTITUTION OF CIVIL ENGINEERS.

February 4th, 11th, and 25th, at 8 p.m. Ordinary Meetings.

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THE INSTITUTION OF MECHANICAL ENGINEERS.

February 14th, at 8 p.m. General Meeting.

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INSTITUTE OF METALS.

As was announced at the Autumn Meeting of the Institute of Metals, held in London in September last, the Annual General Meeting of the Institute, which in former years has been held in January, will next year take place in the Spring, the dates selected by the Council being March 11th and 12th, 1913. By the courtesy of the Institution of Mechanical Engineers the Meeting will again take place at Storey's Gate, Westminster, S.W. In the evening of the first day, the fourth Annual Dinner will take place.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

LIGNOCELLULOSES AND ANIMAL ASSIMILATION.

By C. F. CROSS.

A RECENT paper by A. Zimmerman, in *J. R. Soc. Arts*, 1912, 61, 69, brings into prominent notice the problem of the digestion and assimilation of the lignocelluloses by herbivorous animals. The author's direct interest in the subject was the practical one of finding an industrial outlet for sawdust. He was attracted to the "Classen" process of treating wood waste with aqueous sulphurous acid at elevated temperatures. This method of hydrolytic attack, "limited and reduced," to borrow a descriptive term, effects a substantial conversion of the lignocellulose to fermentable sugar, and it was attempted to make the process the basis of an industrial alcohol; a syndicate, registered as the British Alcohol Syndicate, developed the matter to production on a manufacturing scale, but only to prove that it was unworkable as a profit-earning industry. There were, however, other potential uses of the "converted" product with its 20 to 30% "sugar" contents, and the most obvious was as a constituent of cattle foods. A series of physiologically-balanced mixtures, meals and cakes containing this product are now on the market, sold as "Bastol" foods.

It would appear, by the way, to the initiated that this term is selected as specifically descriptive. The origin, however, is the purely trivial one, B.A.S., with the T as a euphonic addition, representing not bast or bast fibre, but the initials of the syndicate's name above mentioned. We mention this as a noteworthy coincidence.

This endeavour to raise sawdust to definitely industrial rank has given rise to controversy, and the specialist world—agricultural chemists and stock feeders—is torn by divided opinions as to the merits of the claims of the "Classen" product to rank as a food stuff. It would be quite out of place to discuss any such matter in relation to its industrial interests; but the subject involves problems of far-reaching scientific importance to which we may direct disinterested attention.

The digestion and assimilation by the herbivorous animal of the lignocelluloses of ordinary fodder plants, and generally of "annual" agricultural produce, is a well-established conclusion from very many investigations, which in fact finds expression in text-book formulae for feeding values. This aspect of the problem is sufficiently dealt with in the paper above referred to and the discussion which followed. We may, however, remind ourselves that the experimental methods of physiologists by which those values are established, are subject to obvious limitations. The animal is not a mere chemical factory: vital processes are only very approximately represented in a statistical balance sheet; and the proximate analysis of foodstuffs and excreta furnish only broad and general data of measurement.

It is quite clear, moreover, that the agricultural chemists have not considered it necessary to establish any

relationships of the lignocelluloses, as compounds of specific constitution, to any particular effects which they may subserve in the animal.

In fact, the lignocelluloses are assumed to be in the main identical with the laboratory product known as "crude fibre," which is the residue from digestion with hydrolysing acids and alkalis. The resistance of this residue to the hydrolysis of artificial "digestion" is assumed to measure relative indigestibility in the animal. At the same time the statistics of crude fibre estimations have established a definite degree of animal digestion and assimilation. The proportions are variable with varying types of cellular and fibrous tissue; even with the cereal straws which contain more resistant lignocelluloses, the proportion is considerable.

In an elaborate investigation by O. Kellner (*Landw. Vers. St.*, 1900, 53, 1—474), a comparison is instituted between starch, straw cellulose, meadow hay and cereal straws for "Nutzeffekt," with the result of establishing very high values for straw cellulose, notwithstanding its resistance to the purely chemical hydrolysis of the "crude fibre" test. This disposes of the "crude fibre" measure of indigestibility in the animal, and effectually reopens the whole question of the fate or function of the lignocelluloses in this connection.

From the point of view of the constitution of these compounds it is, moreover, important that the physiological problem should be kept open and not prejudged in the grosser terms of the agricultural chemist. To illustrate by a particular point: What becomes of the typical unsaturated groups of the lignocellulose in digestion? As far back as 1866 it was established with a considerable degree of probability that the hippuric acid normally excreted by the herbivora owes its origin to lignocellulose constituents of fodder plants ("Ueber das Entstehen der Hippursäure," Meissner and Shepard, Hannover, 1866), and a few years later an investigation ("Ueber die Rohfaser der Gramineen," A. Stutzer, *Berl. Ber.*, 1875, 8, 575), sought to follow up the indications of the former research by proving the presence of benzene derivatives in the "Rohfaser" complex. The result was negative, but on the somewhat narrow issue of the problem as then formulated. Subsequent researches upon the constitution of the lignone complex have been made more specific through the study of the quantitative reactions of chlorination, as well as with bisulphites, and its characteristic groups are formulated as Diketo. R. Hexene derivatives, with ketene linkings with associated groups. Applying the criterion of the physiological relationships above set forth, there is more than a suggestion of possible transition to benzoyl glycocine under the influence of the animal digestive processes. Moreover, there is an instance of definite conversion of lignone into hydroxy-benzene derivatives under the conditions of a "natural" process of change. The "heart damage" of baled jute, the typical lignocellulose, is a phenomenon to which the only possible external contributory agencies are water, oxygen and bacterial action. A particular specimen

of this product, investigated years ago, contained a quantity of water-soluble derivatives, which yielded protocutecturic acid on fusion with alkalis (*J. Chem. Soc.*, 1882, 41, 92).

This case of transition depended upon an exceptional balance of conditions, for although other specimens of the similarly degraded fibre have been investigated they have not given this particular result, but have been found to preserve the typical characteristics of the original lignocellulose, and to contain no derivative benzene groups as such.

Notwithstanding this evidence there are recent publications which propose for these unsaturated component groups a definitely aromatic constitution closely related to vanillin (Czapek) or comferyl alcohol (Klason). These conclusions have been critically examined in a recent publication ("Researches on Cellulose," III.), and rejected on the purely chemical evidence, which confirms the statement of Stutzer (*supra*). But it appears opportune, with special attention again directed to the physiological relationships of these compounds, to point out that, as regards plant life, benzene derivatives play no part in the more permanent cell structures, and, as regards the herbivorous animals, such derivatives or groups are toxic in their actions, and a general distribution in fodder plants, that is, in the higher mass-ratio of tissue components, is excluded.

There is, however, a more recondite problem presented by the distribution of benzene derivative groups in the complex nitrogenous colloids of the organic world. Characteristic constituents of the proteids are groups closely related to tyrosine or oxyphenylamidopropionic acid, and skatolamido-acetic acid. It would appear that these groups may be derived in two ways from the components of fodders: (a) from their proteid constituents, in which case they may exist preformed; and (b) from components of the lignone order which certainly are transitional to the aromatic series, in which case a somewhat more fundamental transformation would be involved.

Again, there is a certain distribution of hexose derivatives as characteristic constituents of proteids, e.g., glucosamin and glycuronic acid obtained as products of resolution of the chondromucoids (Schmiedeberg, *Arch. Exp. Path. Pharm.*, 28, 111), which suggests a direct genetic relationship of the saturated carbohydrates of fodder plants to assimilated proteids.

On such grounds it would be interesting to construct working hypotheses for direct and specific investigation of the lignocelluloses in relation to animal digestion, and the building of body tissue. It is not necessary to confine these experiments to a particular form of lignocellulose—wood substance as a condensed dehydrated complex is an extreme form, and probably resists entirely the digestive process (*Landw., Vers. Stat.*, 1912, 78, 87). Hydrolysed by the "Classen" treatment it becomes more or less assimilable (*ibid.*). But there are processes of hydration available by which the wood substance may be converted into a permanent colloidal hydrate which at 2 to 3% solids is a jelly-fodder much appreciated, we are informed, by the *Suidæ* of which more particularly *Sus scrofa*! Again, the plant world supplies natural colloid-hydrate forms of the lignocelluloses, as, e.g., the pectin of the white currant (*Lieb. Ann.*, 286, 278; *Berl. Ber.* 28, 2609, Tollens-Cross), which would be available for experiment at certain seasons. But there are multitudinous raw materials which could be selected and suitably prepared in relation to systematic inquiry which is much needed in this direction.

NOTES ON THE EIGHTH REPORT OF THE ROYAL COMMISSION ON SEWAGE.

By S. RIDEAL, D.Sc., F.I.C.

THIS latest issue is most probably in the hands of all interested in the subject, and contains a *résumé* of the Commissioners' conclusions from the evidence they have carefully collected and published in previous Reports and the supplementary researches of their officers. The present Report refers to "the standards to be applied to sewage and sewage effluents discharging into rivers and streams, and the tests which in our opinion should be used." It is added that "in our next and final report we shall deal with methods of disposal not involving water carriage, and with standards in regard to trade effluents."

The Fifth Report of the Commission had concluded from the evidence that the extent of purification necessary varies with the particular conditions of the town and river concerned, but remarked that the statute law hitherto recognises no graduated standards of purity for sewage effluents, and that under the Rivers Pollution Act of 1876 no local circumstances may be taken into account. The Commissioners are of opinion that the law should be altered in this regard, and have given much care to investigating procedure, so that local authorities shall not be required to purify their sewage more highly than is needful to avoid actual nuisance "from smell, over-development of grey algal growths, accumulation of putrefying sewage solids and detriment to fish life."

The data obtained by the officers of the Commission showed a general correspondence between the physical conditions of the stream and the analytical figures determined in the laboratory, and the conclusion was confirmed by experiments with sewage liquors of different strengths diluted quantitatively with water in artificial channels under observed conditions of volume and velocity, with simultaneous analyses. It is mentioned at the end of this Report that "the results of the investigations will be published in a separate volume."

Complete analyses of sewages or effluents are always a complicated matter, involving a large number of estimations, but, for regular control, tests which are short and yet sufficiently accurate must be used, so that any breakdowns in the plant, or exhaustion of purifying power, or irregular changes in the sewage or the river can in the working be corrected or allowed for before mischief is done.

The present Report states that after experience with a great variety of tests, attention was confined mainly to three: (1) ammoniacal nitrogen; (2) oxygen absorbed from permanganate in four hours; (3) amount of dissolved oxygen taken up in five days. It is stated (paragraph 8) that the most delicate chemical index of recent sewage pollution of a river water is to be found in the figure for ammoniacal nitrogen, as the determination is of great accuracy and may be relied on to show very small differences in degree of existing pollution, but is not equally reliable in indicating the *character* of the pollution. We may remark that this figure demands the caution that it may be increased almost innocently from many sources, as from rain water, small quantities of trade effluents, or chemical ingredients of soils, while, as the Reports emphasise, in *recent* sewage pollution fresh urine and some recent sewages contain an amount of free ammonia much less than the other polluting constituents. The albuminoid ammonia test is not directed to be employed. An often-urged objection to the decisiveness of the tests by

the reduction of permanganate is rightly admitted in paragraph 9, which states that this agent may oxidise polluting matters which would not take up dissolved oxygen under natural conditions, at all events not at a rate which would de-oxygenate a stream.

It is inferred from the laboratory experiments that the absorption of dissolved oxygen is a more delicate test than the last, and for that and other reasons the Commissioners consider that it provides the most trustworthy chemical index of the actual state of a stream, and should be adopted for purposes of a standard. It is found that it can easily be carried out, and that it gives concordant and accurate results in the hands of any well-trained chemist. The decision is reached that "if 100,000 c.c. of river water do not normally take up more than 0.4 gm. of dissolved oxygen in five days the river will ordinarily be free from signs of pollution," while "if a river normally gives a higher figure than this it will almost certainly show signs of pollution except perhaps in very cold weather."

In the Fifth Report it will be remembered that standards were provisionally suggested for maximum absorption of dissolved oxygen by effluents, amounting to 0.5 part per 100,000 in 24 hours, 1 part in 48 hours, and 1.5 parts in five days. The Eighth Report considers that "since our main objective is primarily the improvement of rivers, and only secondarily the improvement of effluents," standards should be applied not to effluents alone but to the river water after the admixture, and for this only the test-time of five days is prescribed.

The dilutions of sewage liquors with clean river water required under different circumstances to prevent de-oxygenation below 0.4 c.c. per 100,000 as above are discussed and tabulated, and the formula given for a mixture complying with the standard is:

$$\frac{x + yz}{z + 1} = 0.4$$

when x = parts of dissolved O taken up per 100,000 by effluent;

y = parts of dissolved O by river water above out-fall;

z = dilution (proportion of river to effluent).

A very important point now reiterated is that rivers which have received sewage are not safe sources of drinking water, since they contain large numbers of intestinal organisms. It is practicable to remove or destroy these but the Commissioners consider the cost too serious, and that the operation would be futile unless storm overflows were abolished. The Report finishes with a summary of conclusions advising as a general standard that an effluent must not contain when discharged more than 3 parts per 100,000 of suspended matter, and *with its suspended matter included* must not take up at 65° F. (18.3° C.) more than 2 parts of dissolved oxygen in five days. The other paragraphs of the summary recommend a sliding scale under the approval of the Central Authority as local circumstances require or permit, subject to periodic revision.

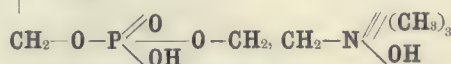
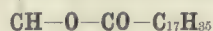
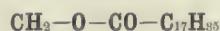
Institute of Metals.—A new Committee has been appointed by the Council of the Institute of Metals for the purpose of assisting the Dominions Royal Commission in their inquiry into the question of the supply of non-ferrous metals and ores in this country. A report dealing with this subject is being prepared by the Committee, of which Professor T. Turner, M.Sc. is the Honorary Secretary, other members being G. A. Boeddicker, Esq., W. Murray Morrison, Esq., Sir Gerard Muntz, Bart., and Leonard Sumner, Esq., M.Sc.

THE LECITHIN AND ALBUMIN INDUSTRY.

By GEOFFREY MARTIN, Ph.D., M.Sc., B.Sc.

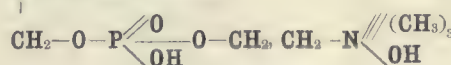
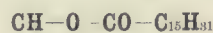
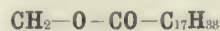
THE lecithin industry originated in the startling discovery of Danilewsky in 1895 that lecithin, when administered to growing animals, was capable of stimulating their growth. He found that animals treated with the substance grew nearly twice as fast as those which had not been so treated. This discovery made a great sensation at the time, and possibly gave Mr. H. G. Wells the idea of his famous novel "The Food of the Gods." Lecithin, which occurs in the brain and nerves of all animals, and also in the seeds of all plants, contains phosphorus in true organic combination, and consequently in a form capable of assimilation and retention by the nerves and brain. Now in various nervous troubles, such as neurasthenia and nervous debility, of all kinds, there is always a great loss of "organic phosphorus," and consequently the great value of a substance like lecithin for repairing the phosphorus waste is obvious. The substance appears to be the most valuable brain and nerve food yet discovered.

It is often sold mixed with casein or albumin, and sometimes dissolved in alcohol. Some of these preparations are very remarkable nervous foods, and are used for stimulating the growth of backward children or for hindering the approach of senile decay in the aged. Lecithin is a complex ester of choline ($\text{HO} \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{N}(\text{CH}_3)_3 \cdot \text{OH}$), glycerophosphoric acid ($\text{C}_3\text{H}_5(\text{OH})_2\text{OPO}_3\text{H}_2$), and fatty acids. Lecithin from animal sources contains stearic acid ($\text{C}_{17}\text{H}_{35}\text{COOH}$), while lecithin from vegetable sources contains oleic acid ($\text{C}_{17}\text{H}_{33}\text{COOH}$), and palmitic acid, $\text{C}_{15}\text{H}_{31}\text{COOH}$, thus:—



Animal Lecithin

(Ester of choline and distearyl glycerophosphoric acid.)



Vegetable Lecithin

(Ester of choline and oleo-palmityl-glycerophosphoric acid.)

The raw material for lecithin manufacture is yolk of egg, brain and nerve matter of freshly slaughtered animals, and seeds like peas and the germ of wheat and cereals generally.

The bulk of the lecithin now on the market is made from yolk of eggs by extraction with solvents. Lecithin is soluble in alcohol and various other organic solvents; while it is sparingly soluble in acetone; and by taking advantage of its different degrees of solubility in various solvents, it is possible to get it in a fairly pure state.

However, the process is not an easy one, as it requires great skill and experience to obtain a nice product, because, being an unstable ester, incautious treatment rapidly hydrolyses it into evil tasting products. Moreover, a quantity of fatty and other impurities are always present in the raw material. Many secret and patented processes are worked. One process of recent development consists in extracting yolk of egg in the *cold* with ethyl acetate, whereby fats, colouring matter, cholesterol, and evil smelling or tasting substances are dissolved out, and there is left behind an odourless, almost colourless mass, very rich in lecithin and albumin. This residue may then be directly used by being ground up, sweetened with milk sugar, and mixed with casein or wheat gluten or similar protein, and is sold in the form of tablets for medicinal purposes. When, however, pure lecithin is required, the mass is next extracted with *hot* ethyl acetate (sometimes boiling ethyl alcohol is used), which dissolves out the lecithin, leaving behind the protein matter. On cooling the solvent the lecithin deposits as a yellowish-white, wax-like mass, which is practically pure. Other worked methods consist in first extracting with alcohol, and then extracting the product dissolved by the alcohol with acetone, which dissolves out fats, colouring matter, and cholesterol, lecithin being left behind.

Now yolk of eggs is an expensive substance; consequently when the great physiological importance of lecithin became recognised, many efforts were made (and are still being made) to extract it from peas or germ of wheat or similar products, the general method employed being extraction with solvents such as alcohol, acetone, chloroform, carbon tetrachloride, ethyl acetate, etc. However, it is difficult to ascertain whether vegetable lecithin has been successfully placed on the market, as the difficulties to be overcome are very great. The demand for yolk of egg for lecithin manufacture has reacted upon the albumin industry.

The albumin is finally evaporated *in vacuo* at 30–50° C., and is sold in thin transparent leaves; 230 to 290 eggs give 1 kilo. albumin (2½ lbs.).

It meets with extensive application for photographic paper manufacture, as a constituent of adhesives and patent foods, as a fining agent, as a mordant in dyeing and calico printing, and, mixed with potassium bichromate, for preparing blocks, the mixture being sensitive to light.

Another variety of albumin is prepared from the blood of recently slaughtered animals. On standing the blood separates into a yellowish serum and a red mass of fibrin containing blood corpuscles.

The German import of dried albumin amounted in 1910 to 612 tons, in value £125,000; the majority came from China. The English import in 1910 was £21,767, the United States in 1910 imported 88 tons (value \$29,000) of blood albumin, 312 tons (value \$269,000) of egg albumin, and 3½ tons of unspecified albumin (value \$1,200). The home trade of each country is far greater than this, of course, but statistics are unobtainable.

ESTIMATION OF MOISTURE.

THE last meeting of the London Section of the Society of Chemical Industry was practically devoted to a discussion on different methods of estimating moisture in such materials as are met with in the everyday work of the laboratory.

The general result of this discussion, when taken in conjunction with the conclusions arrived at by the Committee of the Eighth International Congress of Applied Chemistry on the Determination of Water in Fuel, indicates that the ordinary method of the laboratory may give figures which include changes other than that of mere loss of water.

It was suggested, on the other hand, in the discussion, that in the case of the estimation of water in coal, it was of little use to give figures within 1%, because of the rapid changes which normally take place in coal stored in bulk, owing to surface condensation effects, due to varying atmospheric conditions. If this is so, it is difficult to understand why contracts are made in which the moisture must not vary more than, say, 1%, unless, as in the case of silk, the chief aim is to determine under actual conditions of sale the actual amount of material present *less the water present at the moment of weighing*. Then it would seem that the estimation of 1% would be a valid and useful one.

Particularly interesting was the paper by Messrs. Huntly and Coste (see page 40), as it gave a *résumé* of the work done by the Congress Committee. Mr. Evershed's proposal, that the water should be dried off by the aid of acetone, seemed to give very definite and, seemingly, satisfactory results in the case he exhibited to the meeting.

It is evident that it is difficult to entirely obviate certain changes at 100° in many substances when dried in the air, which may introduce serious errors into the figure obtained for moisture. Also that local variations may be obtained in the temperature of an air oven, or even a water bath, which may materially interfere with the actual estimation itself, if care is not taken to reduce these to a minimum. It was also shown by Mr. Skertchly that drying of food products *in vacuo* gives much lower results than ordinary oven drying, even up to differences of 2%. This has long been recognised in the estimation of water in tannin materials and extracts. The estimation of moisture by calcium carbide seems, on the face of it, an uncertain operation, but Mr. Campbell gave figures which indicated that his modified process may give results agreeing with those obtained with the vacuum process.

Of the three methods, the direct, gasometric and indirect methods of estimation, probably the last mentioned method will prevail. The suggestion that the method of mixing with an excess of a volatile non-miscible liquid (xylene) with subsequent distillation and measurement of the water under the hydrocarbon layer has, seemingly, possibilities, but is certainly involved in itself. Probably the discussion may lead to a more general use of the vacuum drying oven, or modifications in the water oven, to meet recent criticisms.

UNIVERSITIES AND COLLEGES.

THE CHEMICAL DEPARTMENT OF THE UNITED COLLEGE OF ST. SALVATOR AND ST. LEONARD, UNIVERSITY OF ST. ANDREW.

By WALTER NORMAN HAWORTH, D.Sc., Ph.D., Lecturer in Chemistry.

ST. ANDREWS, "the little city, worn and grey" of Mr. Andrew Lang, has attractions other than golf and an exhilarating climate; and in its ancient University, founded in 1411, it cherishes its venerable love of learning in which the modern spirit and the scientific quest find no inconsiderable place.

St. Andrews men are proud to remember that in the foundation of two of our premier learned societies the alumni of our northern University have played an honourable and a distinguished part. Robert Murray, whose name appears on the original charter granted to the Royal Society in 1662, was a graduate of St. Andrews; and another of her sons, Lord Playfair, was one of the early presidents and a founder of the Chemical Society of London.

The Chair of Chemistry in the United College of St. Salvator and St. Leonard was established in the early days of 1808, but for thirty years the tuition afforded in the subject was looked upon as ancillary to the usual course of medical training. In the year 1840 the professorial chair was reconstituted, and under the new arrangement chemistry was taught as a separate subject entirely apart from medicine. The first professor under the amended regulations was Dr. Arthur Connell, F.R.S., and he was succeeded in 1862 by Dr. M. Forster Heddle, the author of the well-known "Mineralogy of Scotland." On Professor Heddle's retirement in 1884, Dr. Thomas Purdie was appointed to the chair, and under his skilful guidance the Department of Chemistry made great progress.

The accommodation then existing for the teaching of the science in the United College soon became inadequate, so that in 1891 a new laboratory with working-benches for fifty students was built and equipped by the generosity of Mrs. Purdie of Castlecliffe, St. Andrews, and presented by her to the University in memory of her husband. This large laboratory is pleasantly situated adjacent to the main buildings of the United College and is accessible by means of an open corridor. Lighting is effected by windows on two sides, and opening from the main room are several smaller side-rooms, utilised respectively for balances, combustion furnaces and blow-pipes, and apparatus for distillations and sulphuretted hydrogen generation. At one end of this building a small private laboratory was provided, and here Professor Purdie carried out his numerous researches on problems connected with optical activity. In this work he collaborated with a succession of research assistants, and a list of those who were his re-

search pupils at one time or another includes such well-known names as Professor J. Wallace Walker, Dr. A. McKenzie, Professor G. D. Lander, Professor A. Findlay, and Professor J. C. Irvine.

The growth of the chemical school during the next twelve years was so rapid as to demand a further extension of premises to provide especially for the training of research students. Accordingly, in 1903, Professor Purdie offered to present to the University a new Institute which should be reserved and endowed specially for research work. This



J. Elliott & Fry.

PROFESSOR JAMES COLQUHOUN IRVINE, D.Sc., Ph.D.

proposal eventually assumed definite shape, and the present research building, opened in 1905, we owe to the munificence and zeal for original investigation of Professor Purdie. The scheme was adopted by the University, and generous aid from the Carnegie Trust was also forthcoming.

The new building adjoins the older teaching laboratories, and, occupying ground near the cliffs east of the town and abutting on the University tennis courts, it commands an extensive view of the North Sea. Its charm, however, is by no means restricted to its fine situation: both in design and planning as well as in its execution, the building is admirably suited to the purpose it is intended to serve. The equipment is on a generous scale, and all fittings and apparatus, as also the general administration, are independent of the ordinary teaching laboratories.

This new research department comprises eighteen rooms, of which six are used as laboratories. The main research laboratory is a large room on the ground floor, well lighted by means of three large mullioned windows facing north, and having accommodation for nine research workers. The equipment includes a separate working-bench (11 ft. in length) for each person, with fittings of high and low pressure water taps, gas, and electric light and electric power; there are three efficient draught-chambers for general use, and four special draught-

The room is lofty, and special care and attention have been bestowed upon the ventilation and heat-



CHEMICAL RESEARCH BUILDING.

ing arrangements. Adjoining, there is a balance room provided, containing also physical instruments such as a refractometer, microscopes, etc., and reference books.

On the same floor are two dark rooms, one for polarimetric and the other for photographic work; also two other laboratories in which special operations are conducted, such as distillations in the very high vacuum obtainable by the Gaede pump, and experiments involving the use of thermostats, incubators, etc. In addition to the usual fixtures of working-places and draught-chambers in these rooms, there are also stone and lead benches. A photograph of one of these rooms appears with this article.

A stone staircase leads to the first floor where the Professor's private room and private laboratory are situated, the latter, to which is attached a small

balance room, being capable of accommodating four students. Adjoining this suite of rooms, which are well lighted and afford a glorious view of St. Andrews



LECTURE THEATRE, PROFESSOR PURDIE, F.R.S., LECTURING.

chambers fitted with steam baths for the evaporation of inflammable liquids. In addition stone benches are fixed along the walls for rougher work.

Bay, a reading room is provided which also serves as a chemical museum; it has been customary to hold the meetings of the University Chemical Society in this room during the Michaelmas and Candlemas terms. Two large preparation rooms and the lecture theatre are approached from the same landing; the theatre has seating accommodation for over a hundred students, exceptional facilities for lecture experiments being provided, along with three large blackboards and sliding screens for lantern work. Students gain admission to the lecture theatre by two doors on the landing of the second floor.

The physico-chemical and gas-analysis laboratory is situated in the basement and is well stocked with the usual apparatus required for this branch of the subject. Next to this room is another laboratory having

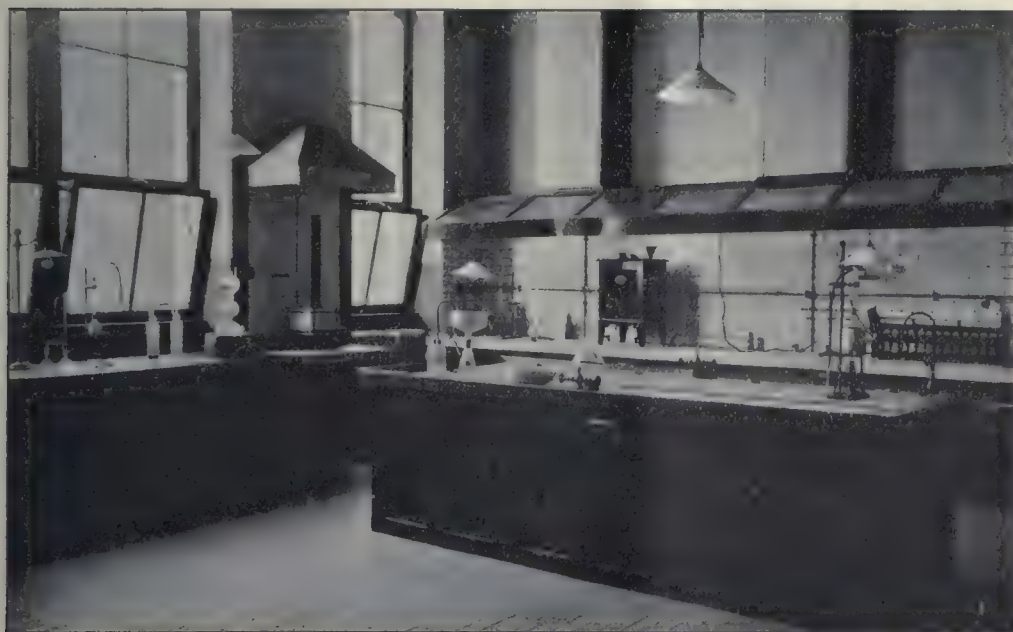
lift for apparatus leads from the service room to each floor in the building.



MAIN RESEARCH LABORATORY.

The teaching and research strength of the department was considerably augmented by the appointment, in 1903, of Mr. J. C. Irvine, D.Sc.,

Ph.D., to a special lecture-ship in chemistry, and his researches, notably on the alkylated sugars and their derivatives, brought the school into greater prominence and extended its reputation in other fields. When therefore, early in 1909, Professor Purdie, F.R.S., sought retirement owing to ill-health, Dr. Irvine succeeded him as Professor of Chemistry and Director of the Chemical Laboratories. Happily Dr. Purdie still continues with us in the capacity of Professor-Emeritus, and maintains his keen interest in all that concerns



ROOM FOR SPECIAL OPERATIONS.

a concrete floor and fitted with draught-chambers, water pumps, bomb-furnaces, etc., where experiments requiring special precautions are conducted. The remaining accommodation in the basement is set apart for two store and service rooms, a workshop, and a boiler-house. All the principal rooms in the department are connected by telephone, and a

the welfare of the department.

The number of students attending the general and special courses averages from thirty to forty, and in the honours classes there are at present twenty-two students. Dr. W. S. Denham, assisted by two demonstrators, supervises the work of the general teaching laboratories, and delivers lectures

to the honours students in physical chemistry; the writer is responsible for other honours courses, including lectures in advanced organic chemistry; whilst the courses of lectures in general chemistry are given by the Professor.

Under existing arrangements the research building is capable of accommodating about sixteen post-graduate workers, and at the present time eleven of these places are filled. Students from other Institutions or Universities who have undergone the usual graduate training in chemistry are welcomed to the laboratories, and those who have had no previous experience of original investigation receive a systematic training in research methods on entering the laboratory. The research work is personally directed by Professor J. C. Irvine, assisted by the writer of this article, and, owing to the provision of a research endowment

taken advantage of by those who are competent to do so.

A considerable number of former research pupils



READING ROOM AND CHEMICAL MUSEUM.

of the St. Andrews School of Chemistry have recently gained important positions in industrial concerns where ability to direct and improve commercial processes is required, and for which

their research training has qualified them. It has been the endeavour of the head of the department to establish a school of chemistry on continental lines, in which original investigation receives proper recognition and emphasis as an essential part of a student's training.

During the past seven years it has been possible for a steady succession of St. Andrews students to qualify for Carnegie Research Scholarships and Fellowships of the value of £100 and £150 a year respectively for two years, and also for the 1851 Exhibition Scholarship.

These are still available for promising students desiring to undertake research, including graduates from other Universities, without regard to nationality. A further inducement to graduates of other institutions is, that on fulfilling certain conditions they become eligible to submit a thesis for the degree of D.Sc.



GROUP OF UNIVERSITY BUILDINGS, SHOWING THE COLLEGE TOWER IN THE BACKGROUND.

fund in connection with the school, the workers receive all necessary apparatus and chemicals free of charge, and no fee of any kind for laboratory work is required. These facilities are unique in respect of research training, and it is hoped that the special conditions which obtain here will be more freely

THE DETERMINATION OF CHEMICAL CONSTITUTION.

By A. W. STEWART, D.Sc.

(Continued from Vol. I, page 416.)

BUT there is another way in which we might look at the question. Suppose that we gave two specimens, a diamond and some graphite, to be examined by purely chemical methods on the one hand, and by purely physical methods on the other. The chemist, relying upon his analyses, would declare them to be identical, consisting as they do of carbon. The physicist on the other hand, from an examination of colour, density, form, etc., would pronounce them to be different from one another. Both investigators would be right; but without the hypothesis of allotropy the two results would seem to disagree.

Now in the matter of physical and chemical methods of constitution on their recent stages, we are evidently coming to the edge of some similar phenomena. Each side brings its own data towards the solution; but we err in trying to explain the matter on too purely chemical lines. If we imagine that we have what (for want of a better term) might be called "constitutional allotropy," then many of our present anomalies might be regarded as special cases of this phenomenon.

Let us take one instance to make the parallel clear. Phosphorus exists in various forms which differ from each other in physical appearance and also in chemical activity. At the back of all these differences in properties, however, we know that we have a fixed body, phosphorus, which will respond to certain reactions in a given way. As a parallel to this let us take the case of an organic compound which has the structure:



This substance contains two ethylenic linkages and is capable of taking up four atoms of bromine or of hydrogen. To this extent, then, it is a perfectly normal substance. But if, instead of allowing it to interact direct with four atoms of bromine, we only add on two, it behaves in what we should term an abnormal way; for instead of forming the dibromide (1), it adds on an atom of bromine at each end of the chain and then rearranges itself to form the dibromide (2):



Now this deviation from the normal in chemical activity might be paralleled by the extreme chemical activity of yellow phosphorus. In the phosphorus allotropes we find a difference in physical properties; and if the parallel is to be even a rough one we should expect to find some anomalous physical properties in organic substances similar to that which we chose as an example above. In actual practice, these substances do show deviations from the normal in many properties such as refractive index,

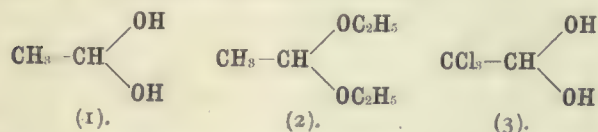
magnetic rotatory power and general adsorption. Thus what we might call the "allotropic double bond" differs from the normal one very much as allotropic phosphorus differs from the other variety.

We are thus led to the idea that just as in some elements we get an allotropy which is probably due to a special arrangement of the atoms in the molecule, so in compounds we get a similar allotropy which manifests itself by exactly analogous properties. It seems probable that if attention were concentrated upon these anomalous cases we might hit upon some explanation—of which Thiele's theory of partial valencies is probably the forerunner—and that this explanation might in turn be applied to the question of differences in chemical activity among the allotropic elements.

At the present time, numerous attempts are being made to co-ordinate the electronic theory with chemical problems (Stark, *Jahrb. f. Radioaktivitat*, 5, 124; *Physikal Zeitsch*, 9, 85; Falk and Nelson, *J. Amer. Chem. Soc.*, 32, 1637); but it must be admitted that there is as yet little sign of a general movement in favour of these views. Yet it can hardly be denied that if the electronic theory justifies the claims made by its supporters it will trench very closely upon the field of chemistry. If our chemical materials are composed of clusters of electrons, then we cannot but admit that our chemical problems are to a large extent governed by electrical properties, and that our most probable line of progress is to graft the electronic idea into our chemical work. If we could get a clear idea of the structure of the molecule in terms of electrons, then obviously we should be able to interpret physical properties and chemical constitution in terms of the true "constitution" of the substance. In the present state of our chemical knowledge, especially in organic chemistry, mathematical expressions would be too refined to be of much utility. What is needed is rather a gross mechanical idea of the molecule in terms of electrons. It might be objected that such a model could not be conveniently figured upon paper and would thus be too clumsy in actual everyday work. This idea is, of course, incorrect. We are able to represent the space configurations of complicated substances like the sugars without having recourse to drawings of tetrahedra; and if we once became accustomed to the electronic idea, we could easily utilise it without much complication on paper.

At the present day there are many common phenomena in chemical work which seem to indicate that the purely chemical view of "constitution" has reached the end of its tether without throwing much light upon the subject. For example, it is

well-known that if we attempt to synthesise a substance having the formula (1) water is always eliminated spontaneously; whereas substances of the type of (2) are perfectly stable; and in the case of chloral hydrate (3) it is very difficult indeed to split off the extra molecule of water:—



These phenomena appear to point to a "state of strain" in the molecule of (1) and to a decrease in the tension in the cases (2) and (3); but at present we have no chemical explanation to account for the facts.

But even if we leave the electronic view out of account until it has been further developed, there are many points at which we might attempt to express more clearly in our formulæ the "unsaturation" or "residual affinity" of certain radicles in a molecule. For example, Staudinger (*Die Ketene*, 1912, 109) suggests that the relative activities of various atoms connected by double bonds might be represented very simply by varying the length of the dotted line of the "partial valency." Thus a comparison between the activities of the carbonyl groups in benzophenone and benzalacetophenone shows that the latter is much more reactive, which is expressed by Staudinger thus:—



Formulæ such as these certainly are better expressions of the chemical character of the compounds than the ordinary expressions could be; and they mark a development of our ideas of molecular constitution in a new direction, for in them some account is taken of the residual affinity of the various atoms, a point which is entirely omitted from the purview of the usual structural expression. If this development is followed out in numerous cases, we shall soon have an easy graphic comparison between the residual affinities of various radicles; and once this is obtained a great step will have been made towards a fuller grasp of the state of things existing within the molecule. Up to the present, we have been content to regard chemical constitution merely as a question of the linkage of atoms, without taking into account the play of forces within the various groupings; but the current trend in chemical thought towards a systematic study of unsaturated groupings promises in the near future to produce a great advance in our ideas of chemical constitution.

X₃.—Prof. J. J. Thomson announced at his recent Royal Institution Lecture that by his method of gas analysis, he had isolated a substance with a molecular (or atomic) weight of 3. This might either be H₃ or else possibly a new element. For the time being he called it X₃. It does not combine directly with oxygen.

CURRENT LEGAL TOPICS.

By WILLIAM JAGO, F.I.C.

THE importance of the subject warrants one in again recurring to the question of new legislation on the purity of food. The interests involved are so many and various, that chemists should take care that their experience and the conclusions based thereon are not overlooked when the period of talk and discussion gives place to that of action. The professional chemists, whose duty it is to assist in the control of the purity of food products, are fortunately well represented in the councils of those who may initiate legislation, and that side of the whole question may be confidently left in their hands. It is doubtful, however, whether the position of the manufacturer and his chemical advisers is so well understood. It is therefore well to take all reasonable means to make that position clear.

The more zealous of our food reformers, when advocating restrictive measures, argue that they are necessary "in the interests of the public." Though they may inflict injury, inconvenience, and loss, on the manufacturer, yet all these must be suffered in order to advance the public weal. At the very outset, issue may be joined on the question whether all such interference is really to the public advantage. The following proposition is a part of the "case" of those who do not deprecate all legislative restriction, but regard it as a weapon that should be used with extreme caution and circumspection:—

"All interference with the manufacture and distribution of articles of food is in itself an injury to the public. Such interference is only justifiable when the injury inflicted is more than compensated by its resultant benefits."

The natural tendency of all manufacturers and distributors is to effect these operations as cheaply and economically as possible. The laws of competition are always tending to cut down the margin of profit to the lowest working limit. Any restrictions and obstacles placed in the way of making and distributing must increase the cost of placing the finished article in the hands of the buyer. And if there is an increase in cost there must also be an increase in price. Ultimately the public has to bear the expense of all such interference and must consider whether the advantages gained are worth the extra amount it will have to pay.

An illustration of the effect of restrictions on the use of raw material in manufacturing processes may be gained from the Local Government Board Report on "The addition of so-called 'Improvers' to Flour," by Dr. J. M. Hamill. Putting it briefly, weak wheat contains soft and inelastic gluten, whereas the strong wheats, which produce large and

finely vesiculated loaves, and in greater number, have a gluten which is plentiful in quantity and highly elastic in quality. Wood of Cambridge claims that the strong wheats are characterised by being richer in water-soluble phosphates than are the weaker ones. It follows that if by the application of a top-dressing of manures rich in phosphates the water-soluble phosphates in the wheat can be increased, then a very definite improvement is made in the quality of wheat. There is probably not a single individual who would regard this treatment as other than legitimate and beneficial. But chemical research has gone a step further than this, and has demonstrated that the addition of phosphates to the flour itself has just the same improving effect at a fraction of the cost. It has also succeeded in demonstrating that various other absolutely harmless salts, used in very much smaller quantities than are necessary with the phosphates, can be employed to produce the same effect. In commenting on the use of such substances, Dr. Hamill does not deny their efficacy but points out that—

"The increased loaf production from a given quantity of flour is one which will appeal only to the miller and baker. The gain in production is due to the increased amount of water which the flour absorbs and to the increase in volume of the dough, resulting from the improved elasticity of the gluten. This naturally means a diminution in the actual amount of flour in each loaf, and, consequently, in nutritive value, so that the consumer in this respect loses by the treatment.

"The protein content of flour is an important matter from the standpoint of nutrition, especially where bread enters largely into a diet. Flour from weak wheats, which are generally poor in gluten, contain less protein than flour from strong wheats, which are rich in gluten. But by the use of 'improvers' flour from a weak wheat is made to simulate flour from a stronger wheat, although as regards protein content it is inferior to the flour which it imitates. . . . The utility of treatment with foreign substances, from the point of view of the consumer, is more than questionable."

The gravamen of the above criticism is that the consumer is prejudiced by such treatment of flour. But do the facts bear out this view? The accusations are (1) that there are increased amounts of water in the bread, and (2) that the improved elasticity of gluten enables flours poor in that substance to be substituted for those which are richer. In the first place the strength of flour does not entirely depend on the quantity of gluten, but also on its elasticity; it follows therefore that some wheats may be high in protein content and consequent nutritive value and yet weak in character. Evidently, any addition which simply improves the elasticity of the gluten of such wheats is not making them simulate wheats of higher protein content, but only bringing them into line with other wheats

of similar composition. The improvement of such wheats does not fall within the condemnation expressed in the second paragraph quoted from Dr. Hamill.

It may be granted that the addition of improving mineral salts will usually increase the water absorbing capacity of the flour, since that property and the ability to yield bolder loaves of a better texture to some extent go hand in hand. But it does not follow that the consumer thereby loses, for a bold well-risen loaf is almost always more digestible than a small, clammy and heavy one from the same flour. It may therefore very well be that the greater digestibility will more than compensate for the slightly less flour in the loaf as a result of the increase in water-absorbing power. The writer has made some tests with the view of elucidating this point. A mineral salt was used as improver in the proportion of 1 part to 4,480 parts of flour. A was the plain all-English flour, while B was the same with the addition of "improver." Loaves of bread were made from each under exactly the same conditions, and baked in tins of the same size. Their greatest heights were A, untreated, 13.3 centimetres, and B, treated, 16.0 centimetres. The following are particulars of the result of comparative digestive tests *in vitro* on each bread:—

	A, untreated.	B, treated
Total proteins in bread..	% 6.76	% 6.86
Total digested proteins of each	5.72	6.04
Percentage of total protein digested	84.61	88.04

It is doubtful whether in practice the use of these improvers results in the successful addition of more than an extra 2 quarts of water per sack. The following tests were made on all-English and all-Manitoban wheat flours. The untreated had 56 quarts of water and the treated 58 quarts of water to the sack of 280 lbs. The following are again particulars of digestion tests:—

	English.		Manitoban	
	Untreated.	Treated.	Untreated.	Treated.
Height of loaves in centimetres	12.9	15.0	16.8	18.2
Total proteins in bread	6.82	6.77	8.25	8.20
Total digested proteins	6.20	6.14	7.06	7.50
Percentage of total protein digested ..	90.90	90.69	85.57	91.46

The respective volumes of the loaves may be gathered from their heights. The larger ones were much better vesiculated, and more porous in texture.

The greater digestibility of the treated samples was very noticeable during the progress of the test, these breaking down into a homogeneous pulp much more rapidly than did the untreated samples. Taking the whole of the last four tests, the average

digestibility as obtained from total protein digested was distinctly in favour of the treated flours, being 6.82 as against 6.63%. The greater digestibility more than made up for the effect of the slightly less proportion of flour present in the loaf, and certainly these results cannot be said to afford any support to the view "that the consumer, in this respect, loses by the treatment."

A more important criticism is that which deals with the lowering of nutritive value of bread by the substitution of a weaker wheat, poorer in protein, for one having higher protein content. It is difficult to deal conclusively with this objection, for the reason that there are several other factors which govern the price and commercial value of wheat, flour, and bread, beside the protein nutritive value. Principal among these is the fact that the very strong wheats of which Manitoban may be taken as an example, yield comparatively harsh, dry, and flavourless bread, as against the softer and weaker wheats of the English type, the bread from which is sweet, moist, and full-flavoured. Taking the present prices of Manitoban and English wheats, they are quoted on the London market at 35s. 4d. and 33s. 7d. per quarter respectively. The total protein content in bread made from each is 8.25 and 6.82 respectively. If their selling prices depended on their strength or protein content only, English wheat would be worth 29s. 2½d. or say 29s. 3d. per quarter. The difference between this figure and the actual selling price, 33s. 7d. - 29s. 3d. = 4s. 4d., is due to certain other properties which have a monetary value in the eyes of the public, and which consequently are of value to the consumer. One cannot with certainty translate the difference in prices of wheats into their equivalents in flour, but if from English wheat at 33s. 7d. a grade of flour worth 28s. per sack is extracted, then proportionately the corresponding grade from Manitoban wheat would be worth 29s. 5½d., or say 29s. 6d., per sack. Similarly, the 4s. 4d. difference between protein value and selling value per quarter of wheat, above given, becomes a difference of 3s. 7d. per sack on the flour. These proportionate figures will be sufficiently accurate for our illustration. In Canada, the natural home of strong Manitoban flour, its comparative flavourlessness is compensated by the addition of large quantities of sugar or malt extract, and butter, lard, or other fat, in bread making. In England, the desired improvement in flavour is obtained by the use of English or other "flavoury" wheats.

It is now possible to investigate a little more closely the effect of the addition of an improver to a blend of wheats or flours. The untreated Manitoban flour would make a loaf about equal in volume to that yielded by a mixture of equal quantities of treated Manitoban and English flours. The actual flour cost of the mixture would be 28s. 9d. per sack. The total digestive protein content of the breads would be—Manitoban, untreated, 7.06, and half Manitoban and half English, treated, 6.82%. The protein nutritive value of the two, expressed in terms of price, would be, Manitoban 29s. 6d., with

7.06 protein, and therefore for the half-and-half mixture containing 6.82 protein, 28s. 6d. per sack. But the mixture, in virtue of its consisting of half English must be credited with half the extra value due to factors other than protein content, that is the half of 3s. 7d. = 1s. 9½d. per sack. Adding this sum to the protein calculated value of 28s. 6d., the total is 30s. 3½d. per sack as against 29s. 6d., the value of untreated Manitoban wheat flour. In other words, the slight loss in available protein is more than compensated by the presence of other qualities to which the public attaches a definite money value; and again, it is difficult to see "that the consumer loses by the treatment."

The last year's harvest was, as is well known, a very bad one; English wheats especially were excessively damp, more than ordinarily weak, and often sprouted. These defects were so great in many cases that the flour from such wheats would not have made a saleable loaf. By the judicious use of "improvers," the gluten of these wheats has been so raised in toughness and elasticity, as to permit the wheats to be used in flour manufacture. Exact data on which to form an estimate are not available; but it is not a very extravagant assumption to make that 5% more of English wheat has been used than would have been possible without the aid of the improving action of mineral salts. If this be so, the actual value of the English wheat harvest has been increased by 5%, no inconsiderable item in the annual national balance sheet. If by this means a shortage of 5% of wheat supply has been remedied, a very notable economy in the price of bread has been effected. It must be remembered that 5% shortage of supply of any article for which there is a steady demand, means far more than 5% increase in price. One of the shrewdest operators on Mark Lane (the London Wheat Market) recently assured the present writer that under favourable circumstances, a 5% shortage might possibly cause a 20% rise in prices. If this figure be halved, a 10% rise would be a most serious blow to the consumer. If the use of flour "improvers" has helped to avoid this, then a most valuable service has been rendered to the community. It is significant that notwithstanding the late bad harvest, English wheats have been successfully used in larger proportions than was expected, and there has been no rise in the price of bread.

Cheap food is dependent in part on the easy working of very complicated machinery in which the requirements of the public taste, supply and demand, and the laws of competition fulfil important functions. Anything which impedes the smooth working of this machinery must affect the interests of the consumer. For this there must in certain cases be justification and compensation. There are two very excellent guides for the would-be legislator: (1) Nothing must be permitted which is to the injury of the public health; (2) nothing must be done which is to the "prejudice of the purchaser." The second rule must, however, be applied with skill and the fullest knowledge; otherwise injury may be inflicted where it is least intended.

MOLECULAR PHYSICS.

By J. A. CROWTHER, M.A. (Fellow of St. John's College, and Demonstrator in Physics in the Cavendish Laboratory, Cambridge.)

CHAPTER II.

THE PHYSICS OF THE ELECTRON.

THE general appearance of an ordinary discharge tube is perhaps familiar to most of my readers. It is represented somewhat diagrammatically in Fig. 1. Covering the cathode C is a velvety light known as the cathode glow. Beyond this is a comparatively dark space, named after its discoverer Sir William Crookes. If the pressure in the tube is fairly high this Crookes dark space will be so close to the cathode and so small as to be hardly visible. Beyond this dark space is another luminous area, the negative glow, bounded on the side remote from the cathode by still another obscure area, the Faraday dark space. The length of the tube occupied by these phenomena depends mainly on the pressure of the gas, and is practically independent of the size of the tube, the remainder of which, however long, is filled with a bright light known as the positive column, which is frequently, though not necessarily, divided into numerous striæ. It is the

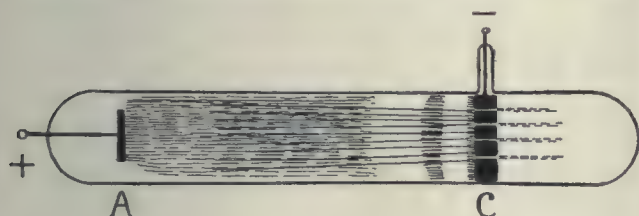


FIG. 1.

light from this positive column that is generally employed in the spectroscopic examination of gases in the discharge tube.

If the pressure is fairly low another phenomenon may be distinguished. Proceeding normally from the cathode and penetrating in straight lines across one or more of the dark spaces may be seen faint bluish streams of light, known as the cathode rays. As the pressure is still further reduced these rays become relatively more and more important, and penetrate further and further, until finally they fall upon the glass walls of the discharge tube, exciting there a greenish phosphorescence. Meanwhile the Crookes dark space has grown until it occupies practically the whole of the tube, the remaining parts of the ordinary discharge being represented by the glow on the cathode and a single patch of light near the anode itself.

The nature of the cathode rays remained for some time in doubt. However, in 1895 Perrin showed that they transported a negative charge, and in the following year Professor Sir J. J. Thomson proved conclusively that they consisted of streams of negatively charged particles, moving with

extremely high velocities and having a mass in all probability much less than that of a hydrogen atom.

Let us continue for a moment the study of the discharge tube. It had long been known that if a solid obstacle were placed in the path of the discharge a shadow of the object was cast by the cathode rays on the opposite wall of the tube. It was noticed that if the obstacle was placed within the Crookes dark space a shadow was also cast on the cathode. That is to say, there must also be rays in the tube proceeding in the opposite direction to the cathode rays and falling upon the cathode itself. By using a perforated cathode, as shown in the diagram, these rays become visible as faintly luminous streaks of light, coming from each of the perforations, and exciting a faint mauve phosphorescence where they strike the walls of the tube. These rays which carry a positive charge and have a mass comparable with that of an atom, form the positive particles to which we have already alluded.

The high velocities of these particles give them, as we have seen, sufficient energy to produce luminous effects when they fall upon suitable screens. The additional fact that they carry an electric charge enables us to determine not only the velocity, but also the ratio of the mass of the particles to the charge which they carry.

The general problem of the motion of an electrified particle when moving under the action of electric and magnetic forces is one of some little complexity, though complete solutions have been given by various mathematicians. Fortunately the special cases which are required for our present purpose lend themselves readily to the simplest treatment.

Suppose that a particle of mass m and charge e is moving with a velocity v at right angles to a magnetic field of strength H . In one second the charge e will have moved through a distance v cms. We may therefore regard the path of the particle as a sort of conductor v cms. long, carrying an electric current whose strength is e . The mechanical force on such a conductor when placed in a magnetic field is known from the laws of electro-magnetic induction to be equal to the strength of the field multiplied by the current and the length of the conductor, that is to the product $H \cdot e \cdot v$. Further, this force is at right angles to the direction of the current and to the lines of force in the magnetic field. A little consideration will show that under these circumstances the path of the particle is changed from a straight line to a circle described in a plane at right angles to the direction of the lines of force in the magnetic field.

Let r be the radius of this circle. A particle of mass m moving round a circle with a velocity v exerts a centrifugal force tending to urge it away

from the centre of the circle. The value of this is known to be

$$m \cdot v^2/r.$$

Now for equilibrium the force tending to urge the particle away from the centre must equal the force due to the magnetic field tending to draw it in. Thus we have

$$\begin{aligned} H \cdot e \cdot v &= m \cdot v^2/r \\ \frac{m}{e} \cdot v &= H \cdot r \end{aligned} \quad (a)$$

Again the particle carries an electric charge. It can therefore be deflected by an electric field. Let X be the strength of the electric field. Then the force experienced by the particle is equal to $X \cdot e$ and acts upon the particle in the direction of the lines of electric force. If now we arrange our apparatus so that the electric field and the magnetic field are at right angles to each other, the forces upon the particle due to the two fields will act along the same straight line, and by properly adjusting the sign of the electric field we can make the two forces oppose each other. It will then be possible to find a value for the electric field such that the two forces just neutralise each other and the particle goes on its path without deflection. When this is so we know that the mechanical forces on the particle due to



FIG. 2.

electric and magnetic fields just balance each other. That is

$$\begin{aligned} H \cdot e \cdot v &= X \cdot e \\ v &= X/H \end{aligned} \quad (b)$$

Thus if we apply to the moving electrified particle simultaneously an electric and magnetic field of such magnitudes that the particle pursues its path without any deviation, the ratio of the strengths of the two fields will give us directly the velocity of the particle. If, further, we can measure the radius of the circle into which the path of our particle is bent by the action of the magnetic field alone, we can, by equation (a), determine the value of the ratio m/e , or the mass to the charge for the particle we are

investigating, since the value of v is now known from the previous experiment.

This ratio of the mass to the charge is one of the utmost importance in molecular physics. It may be noted that for ions in solutions it is the quantity of matter associated with the transference of unit quantity of electricity, that is to say, the electrochemical equivalent. According to the latest values, the electrochemical equivalent of hydrogen ions in solution is .0000109 gm. per coulomb. The values of the ratio for other ions can be deduced from this

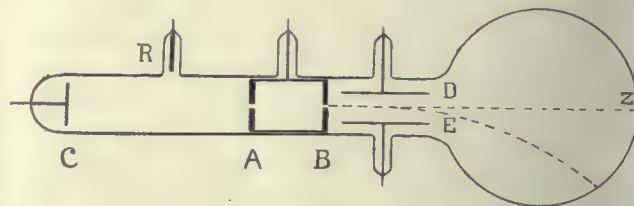


FIG. 2A.

and a table of combining weights in the usual way, since every ion in solution carries by Faraday's laws either the same charge as the hydrogen ion or some simple multiple of it.

Owing to the way in which the volt and the ohm have been defined, the former as 10^8 and the latter as 10^9 absolute electro-magnetic units, the absolute unit of electro-magnetic charge is ten times the coulomb or practical unit of charge. The value of m/e for hydrogen in absolute units of charge is, therefore, .000109, or just a little greater than 10^{-4} gms. per absolute electro-magnetic unit of charge.¹

The principles just explained found their first application in the experiments of Professor Sir J. J. Thomson, on the cathode rays, experiments which may well be said to mark a new era in science. The experimental methods used by him have been modified and improved upon in the light of subsequent discoveries, and the accuracy attained in the measurements greatly increased. In principle, however, the experiments remain the same, and on account of its historic interest the original apparatus used in these experiments will be described. Fig. 2 is taken (by kind permission of Professor Sir J. J. Thomson) from a photograph of one of the tubes used by him for the experiment. The arrangement of the various parts will be seen more clearly from the diagrammatic representation in Fig. 2A.

The cathode of the discharge tube is at C, and consists of an aluminium disc supported by a rod

¹ The science of electricity is burdened with two distinct systems of units for the measurement of electrical magnitudes, the one founded on the consideration of the force with which two similar charges repel each other, the other on considerations of the induction of currents by magnets. The practical system of units is founded upon the latter, the volt being 10^8 and the ohm 10^9 absolute electro-magnetic units. The ampere and coulomb are thus 1/10th of the absolute units of current and charge. To make confusion worse confounded, it has become usual in works and original papers on these subjects to give the value of m/e in electro-magnetic units, while the value of e itself is usually given in electrostatic units. Our statement that the force on the electron due to the magnetic field is equal to $H \cdot e \cdot v$ implies that we are using the absolute electro-magnetic system of units, as this system has been defined in such a way as to make this statement true. As this system is the one more closely related to the units in actual use, we shall employ it throughout, except where the contrary is explicitly stated.

of the same metal and connected with the outside of the tube by a platinum wire sealed through the glass. The anode R is an aluminium rod placed in a side tube, while facing the cathode is a thick metal disc A, filling the tube but pierced with a small hole through which the cathode rays can pass in a narrow pencil. To define this beam of rays still further, a second metal disc B pierced with a still finer hole is placed some distance behind A. For convenience these two discs are mounted in a metal tube as shown in the figure. This tube and the anode R are connected to earth, while R and C are connected to the terminals of a large induction coil as shown in the photograph.

Thus, when the discharge is passed between C and D, a very fine well-marked pencil of cathode rays emerges from B. It is then made to pass between two parallel plates D and E of aluminium which can be charged to any required difference of potential by connecting them to a large battery of small accumulators.

This part of the tube is also placed between the poles of the little electro-magnet shown in the photograph, the lines of magnetic force being at right angles to the plane of the paper and therefore at right angles to the electric field. Finally, the stream of cathode particles falls upon the walls of the bulb Z which are covered with powdered zinc blende, its presence being marked by a spot of bright green phosphorescent light at the point of impact. The position of the spot in the original experiments was read off on a scale pasted on the outside of the tube.

To perform the experiment the magnetic field is first applied and the deflection of the spot of light measured. From this deflection and the dimensions of the different parts of the tube it is possible to calculate the radius of the circle into which the path of the rays has been bent by the magnetic field. The deflected and undeflected paths of the particles are indicated by the dotted lines in the diagram. The electric field is then applied and the difference of potential between the two plates gradually increased until the spot of light is brought back to its original position. The ratio of the electric to the magnetic field is then equal to the velocity of the cathode particles. The value of the ratio m/e can be calculated from this velocity and the known magnetic deflection as explained above.

The experiments were not without difficulty. It was at first found very difficult to obtain any deflection of the particles by means of an electric field. This was found to be due to the fact that the passage of the cathode rays through the residue gas in the discharge tube rendered it more or less conducting, so that the particles were moving through what was practically a closed conductor and were thus hardly affected by the external electric field. It was necessary in order to eliminate this effect to work with very high vacua.

On making the calculations it was found that the velocity of the particles depended principally upon the potential of the discharge, and to some extent also on the pressure of the residual gas in the tube

and the nature of the electrodes and the gas in the tube. Even in the same tube the velocity of all the rays was not the same, so that on applying the magnetic field the single spot of light made by the cathode beam on the zinc blende screen was spread out into a little magnetic spectrum, as we may call it, each point of which corresponded to cathode rays moving with a definite velocity. In tubes at an exhaustion suitable for these experiments the velocities range, as a rule, from 2×10^9 to 3×10^9 cms. per second, or about 1/10th of the velocity of light.

On evaluating the ratio m/e it was not found to



FIG. 3.

suffer similar variations. The original experiments showed and this has since been confirmed by many subsequent experiments, that, whatever the nature of the gas in the discharge tube, whatever the material of the cathode, whatever the working potential of the tube, the value of the ratio of the mass of the cathode particle to its charge is always the same. According to the latest determinations the value of this constant is 5.65×10^{-6} gms. per unit of charge.

Again, although we have so far considered only the case of the cathode rays, these are not by any means the only source of these corpuscles, or electrons as they are now called. Similar electrons are given off in quantities from a clean metal surface when illuminated by ultra-violet light, or from the surface of the liquid sodium-potassium alloy under the action of the light from an ordinary candle. Rontgen rays produce them whenever they fall upon any material object, and it is interesting to note that the velocity of the electrons thus produced is the same as that of the cathode rays in the Crookes tube from which the Rontgen rays proceed. Electrons are also emitted from incandescent metals at a high

temperature, and in very large quantities when certain metallic oxides and notably those of barium and calcium are raised to a red heat. These electrons have very little velocity of their own, but may very readily be given one by acting upon them with an electric field. If the heated oxide is raised to a potential P in absolute units, the work done on the electron by the field will be $P \cdot e$. If v is the velocity acquired by the electron, its kinetic energy is $\frac{1}{2}mv^2$. Hence, by the principle of the conservation of energy $P \cdot e = \frac{1}{2}mv^2$ or $v^2 = 2P \cdot e/m$. Thus by suitably altering the potential of the hot oxide we can give to these electrons a suitable and known velocity.

Fig. 3 is a reproduction of an actual photograph of such a discharge. The cathode is a platinum strip carrying a minute speck of barium oxide, raised to a red heat by means of an electric current and charged to a potential of -240 volts from a cabinet of small accumulators. The electrons given out by the heated BaO are projected by the field in a narrow pencil and are rendered visible by their action on the residual molecules of air in the exhausted tube. In the photograph a magnet has been placed behind the tube so that there is a magnetic field at right angles to the paths of the electrons, which are thus bent into the arc of a circle as shown in the figure. The fact that the circle is not completed is due to the gradual diffusion and absorption of the electrons by collision with the molecules of the gas in the tube.

The value of the ratio m/e for these electrons has been measured by their discoverer Wehnelt and others. It may be noticed that as the potential P to which the cathode is raised is equal to $\frac{1}{2}v^2 \cdot m/e$, it is only necessary to measure the radius of the circle into which the rays are bent by a magnetic field of known strength H in order to be able to calculate both v and m/e . This fact has been applied by Lenard and others to measure the value of m/e for the electrons given off by metallic surfaces under the action of ultra-violet light.

TABLE I.

Observer.	Source of electrons.	e/m e.m.u. per gm.
Kaufmann .	β -rays (slow) from Radium	1.77×10^7
Simon .	Cathode rays	1.72×10^7
Ewers .	β -rays from Polonium .	1.7×10^7
Classen .	Cathode rays	1.774×10^7
" .	Hot lime	1.776×10^7
Woltz .	β -rays (slow) from Radium	1.767×10^7
Bestelmeyer .	Hot lime	1.766×10^7

The above table (Table I.) gives a few of the more recent determinations of the ratio e/m for electrons from different sources. It will be seen that within very narrow limits indeed, especially considering the difficulties of the experiments, the ratio of the charge to the mass is the same for all electrons, whatever their origin and whatever their velocity, and differs very little from 1.77×10^7 . The value of m/e or the electro-chemical equivalent

of the electron, if we may so call it, is therefore 5.65×10^{-6} . For the hydrogen atom, as we have seen, the value is about 10^{-4} . If we could assume that the charge e is the same for the electron as for the ion in solution we see at once that the mass of the electron must be only about $\frac{1}{1800}$ part of that of the hydrogen atom.

For this assumption, however, very little direct evidence could be adduced at the time it was made. It was one of those strokes of genius which have proved to be correct. To determine absolutely the mass of an electron we must find some method of determining the value of the electronic charge e . Fortunately this also has proved possible, owing to a discovery made in the Cavendish laboratory by Mr. C. T. R. Wilson.

If a space saturated with water vapour is suddenly chilled the surplus water over and above that which would saturate the space at the lower temperature in general separates out in little particles of water, forming within the space a thick mist or cloud. It was, however, shown many years ago by Aitken that this condensation always commenced round minute particles of dust, particles often far too small to be visible, yet sufficiently material to be caught by a well-packed tube of cotton wool. In the absence of these particles he found that a very considerable degree of supersaturation could be produced without any deposition of water and without any appearance of cloud or mist, and that it was only when the supersaturation became at least eightfold that a mist or cloud was produced. It appeared then that for a lesser degree of supersaturation than this the water vapour must have some nucleus about which to condense before a drop could be formed.

Gases under ordinary conditions are almost perfect insulators. Under the action of certain agents, such, for example, as Rontgen rays or any of the rays from radio-active substances, a gas becomes more or less conducting. It has been shown that this is due to the creation in the gas of systems, some negatively, some positively charged. In all probability these are produced by the ionising agent expelling a negative electron from the atom through which it passes, leaving the remainder of the molecule positively charged. The negative electron thus set free soon attracts to itself one or more atoms just as an uncharged pith ball is attracted by an electrified ebonite rod. The gas thus becomes filled with oppositely electrified systems consisting of clusters of three or four atoms together, which move under the action of an electric field in exactly the same way as the ions of an electrolyte move in the electrolysis of a solution. There is this difference, however, that, whereas the electrolytic ions are stable, the gaseous ions if left to themselves, gradually re-combine to form neutral molecules. Thus unless the supply is kept up by the continuous action of the ionising agent the conductivity will soon die away.

(To be continued.)

CHEMICAL ENGINEERING.

ELECTRIC FURNACE METHODS OF IRON AND STEEL PRODUCTION.

By JOHN B. C. KERSHAW, F.I.C.

THE electric iron and steel industry is a product of the twentieth century.

Ten years ago electric steel was merely a laboratory curiosity, and few chemists or metallurgists had seen any specimens of this new product of the electric furnace.

Five years ago the new industry had just commenced to develop, and the more advanced and

widely employed by progressive steelmakers in both Europe and America, and the electric steel industry is already well established and of considerable importance. The electric smelting industry, on the other hand, has only made headway in two countries, where the special conditions referred to above have been found favourable to its development, namely, in Sweden and in California; and in the former

country alone can a healthy and progressive industry be said to exist. While the annual output of electric pig-iron and pig-steel is still too small to be recorded, the annual production of electrically refined steel has grown from 30,000 tons in 1908 to over 200,000 tons in 1912, and, when the larger furnaces that are now being installed commence to produce steel, the output will be greatly increased, and may attain 250,000 tons per annum in 1913.

Compared with the world's total output of steel, these totals are, of course, small and insignificant; but when one realises that only ten years ago electric steel was largely a novelty, and that the steel manufacturing industry, owing to its age and importance, and also to the capital invested in it, is one of the most conservative and settled of all industries, the progress made in the period 1907—1912 is seen to have been quite notable, and,

considering all the circumstances of the case, remarkably rapid.

Two other forecasts relating to the development of electric steel refining are also now in course of realisation, namely, the restriction of the electric furnace to the last stage only of the steel-making process, and the use of blast-furnace or coke-oven gases for generating the electric energy required. In Germany, at the works of Le Gallais Metz & Co., at Dommeldingen, and also in America, at one of the large works in Chicago, owned by the United States Steel Corporation, gas engines using the waste gases of the blast furnaces provide a large portion of the



GENERAL VIEW OF POWER HOUSE AT LA PRAZ, FRANCE.

scientific steelmakers had begun to make inquiries concerning this new method of steel refining by aid of electric heat.

To-day, electric furnaces for steel refining are a common feature in all of the larger and more important steel works in Europe and America, and the electric iron smelting industry is now established in Scandinavia on what appears to be a sound commercial basis.

The developments of the five years that have elapsed since the lines¹ were written have to some extent proved the correctness of the forecast. Electric steel-refining furnaces and processes are

¹ In a small handbook entitled "The Electric Furnace in Iron and Steel Production," 1907 (The Electrician Printing and Publishing Co.), the writer, after describing all the well-known types of electric furnace, summarised the position at that date, in the following words:

"The use of the electric furnace for iron ore reduction is, therefore, in the writer's opinion, not likely to undergo any industrial development at present, excepting under very special conditions."

"In countries like Norway and Switzerland, with abundance of water-power that can be developed at very low cost, it is possible that a native iron-smelting industry might be established, if iron ore and lime are found in the locality of the water-power. But, here again, special conditions will be required to render the industry a financial success, and it is unlikely that the iron will be able to compete in price in the open market with the product of the ordinary blast-furnace."

"Taking the cost of the electrical horse-power year at £2, and an average power consumption, we have the following costs:—

1. Steel from molten scrap, 2s. 6d. (400 kw.-hours).
2. Steel from cold scrap and pig 5s. (800 kw.-hours).
3. Pig-iron from ore, coke and lime, charged cold, 15s. 6d. (2,600 kw.-hours).
4. Pig-iron from ore, coke and lime, charged hot, 12s. 5d. (2,000 kw.-hours)."

"In the manufacture of best crucible steel, however, it is customary to assume that between 2½ and 3 tons of coke are consumed per ton of steel produced. At the present market price of coke (17s.) the advantage is, therefore, on the side of the electric refining furnace."

"As regards the electric smelting processes, it is necessary to remember that coke is still required to reduce the oxide of the iron ore

current required by the electric refining furnaces. A similar system of power generation is to be employed at a large ironworks in the North of England, where an electric plant is now being installed. In this case, coke-oven gases are to be used in conjunction with the waste gases from blast furnaces for driving the gas engines; and the whole plant, including rolling mills, blowing engines, auxiliary motors, and electric and open-hearth furnaces, will be operated without burning a single ton of solid fuel for either power or heating purposes. According to Campbell, the cost of power at this installation will be under .25*d.* per kw.-hour, and, if the plant is well designed and repairs are not unusually heavy, the cost may be found to work out 25% below this estimate.

As regards the advances in other directions, the capacity of the furnaces has been increased five-fold, and the power consumption reduced by 33% in the period under review. In 1907, the Heroult furnaces at La Praz, taking 480 kws., and producing 3 tons of metal at one heat, were the largest in actual use; during 1912, furnaces producing 15 to 25 tons of metal per charge, and consuming 2,000 to 3,000 kws. of electrical energy have been installed both in Germany and America, and are yielding good results.

The chief advantages obtained with these large furnaces are, that radiation losses are reduced, and that a metal possessing more uniform chemical and physical properties can be obtained than from a succession of small heats. As regards power consumption, the best average results obtained in 1907

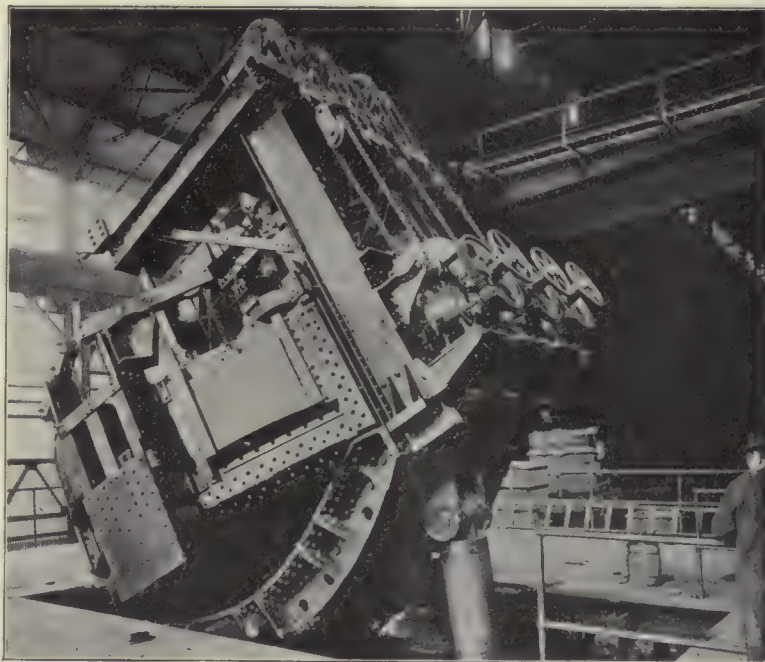
to the metallic state, and that the only fuel saved is that used in the blast-furnace for heating purposes. In the best modern smelting practice only 16 cwt. of coke are required to reduce the ore per ton of pig iron produced, and of this total 6.5 cwt. are required to reduce the ore. The saving in coke by the electric furnace method of smelting cannot, therefore, exceed 9.5 cwt., or, at the present price of coke, 8*s.*"

"These considerations show that the prospects for the electric refining processes are much brighter than those for the electric smelting processes, since the saving of coke in the latter is too small to balance the large expenditure upon electric power. The horse-power year would, in fact, have to be supplied at the extraordinarily low cost of £1 in order, to compete with the modern blast-furnace, and the localities where it can be produced at this figure are certainly few in number. For the present, therefore, the application of the electric furnace in the iron and steel industries is likely to be restricted as a general rule to the refining processes, by which pig and scrap steel are converted into higher-priced products. In these branches it is likely to be very widely employed, and to have a most important effect upon the future development of the whole iron and steel industry."

were 800 kw. hours per ton (2,000 lbs.) of metal produced, using cold scrap as raw material, whereas to-day returns for a recently erected refining furnace show a reduction of 28% on these figures, and a consumption of only 575 kw.-hours under similar conditions of work. The consumption and cost of electrodes have also been reduced 50% during the past five years by many improvements in the methods of manufacture and of use. Further savings in this direction may no doubt be expected.

Turning now to the field of application for the electric furnace in the steel industry, we find that, whereas five years ago only the finer and higher priced varieties of tool steel and special alloys were

being manufactured, to-day it is being employed for a great variety of products, including steel for axles and tyres, gun-steel, billets for wire and plates, and rail and girder steel. The application of the electric furnace as a heating furnace only, in the production of fine castings, is also extending, and in Germany, France, England, and America several installations of this character can now be found in operation. The advantage here is that the higher temperature obtained by the electric method of



HEROULT 15-TON STEEL REFINING FURNACE AT CHICAGO.

heating yields a more fluid metal, and a better separation of the gaseous and other impurities of the steel is thereby obtained.

According to Heroult (Transactions of the Eighth International Congress of Applied Chemistry, New York, September, 1912), it has been found quite unnecessary to anneal some of the low carbon steels for casting purposes made in the electric furnace, the chemical and physical properties of these steels being quite equal to those of the best brands of rolled or hammered mild steel made by the ordinary methods.

Another application of the electric furnace, which has been found most valuable, is as a melter and mixer of the miscellaneous scrap alloys and scrap steels, which accumulate in all foundries where the special steels are made. Chrome, nickel and vanadium steels for automobile castings can be manufactured by melting miscellaneous steel alloy scrap, and by making the necessary additions to bring the composition up to the required specification. Another application which is being developed

at the present moment is that of using an electric furnace for maintaining steel in a "resting" state at a pouring heat, for 1 or 2 hours, to allow a more complete separation of the slag and gases entangled in the molten metal.

The extension of the field of application of the electric furnace in the steel industry, from the production of high-class crucible steel, through the intermediate grades of steel, to that of rail and constructional steel has, however, been one of the most

been laid on railway tracks out in the Western States of America, and it is reported that, so far, not one single electric rail has failed. In Germany also very favourable experience has been obtained with these rails, and it is quite possible that the savings resulting from their longer life and greater freedom from breakage may more than counterbalance the extra cost of the electrical treatment. For it must be understood that the electric furnace, when applied to the production of rail and girder steel, does not seek



STASSANO REFINING FURNACE AT NEWCASTLE.

striking features of the development of the past five years.

The question that now demands an answer is: Can this extension be justified by the results obtained and can the electric finishing process be employed to supplement the open-hearth process of manufacture for ordinary rail and girder steel? On this particular point opinion at present is sharply divided; and, in the writer's opinion, it will only be by the practical test of some years' experience that the question will be decided. Both in America and in Germany large quantities of rail steel have already been made in the electric furnace, and these rails are now undergoing the tests of actual service on the railway systems of the two countries named.

Five thousand tons of electric steel rails have

to eliminate the Bessemer or open-hearth furnace, but to take the metal they produce, and, by the application of special heat treatment in a neutral atmosphere, to carry the refining operations a stage further, and thus to produce a purer and more durable metal.

Serious railway accidents due to rail breakages have been increasingly common (especially in U.S.A.) in recent years, and any improvement in the quality of the rail steel that will lead to a reduction in the number of these accidents may be quite worth paying for.

However, whether such an extension of the use of the electric furnace is to occur at once in the United Kingdom, in Germany, and in America, or only with the gradual exhaustion of the coal supplies

its field of utility is already sufficiently wide and important to justify a close study on the part of steelmakers of the developments of the past five years.

The following extract from a valuable paper read by Mr. Donald F. Campbell, in London, in the autumn of 1911 (*Transactions of the Faraday Society*, 7, 1912), proves the necessity for study of what has already been achieved in this particular branch of electro-metallurgy, and may serve as a foreword to that more extended study of the subject which this article is designed to promote.

"It must be remembered that a large number of engineers of the highest technical training and international experience are constantly engaged in improving furnace design and metallurgical methods on behalf of powerful industrial organisations. Careful and expensive experimental work has been going on for years, and many of the furnaces and processes, which are continually being patented and published, have been tried and abandoned by those controlling large electro-metallurgical works. *Improvement must be looked for by increasing the general efficiency of the best processes we have at the present time, rather than by radical changes in furnace construction.*"¹

"In all questions of design it is essential to bear in mind first and foremost the metallurgical requirements, and the electrical considerations always must take a purely secondary place. The neglect of this principle has caused the failure of the majority of the numerous furnaces that in recent years have been described in technical journals, but abandoned because they were based on incomplete theoretical data with little or no commercial practice, whereas *the most successful electric steel furnace of to-day follows as closely as possible the best basic open-hearth practice, with the simplest possible application of electrical heat energy.*"¹

(To be continued.)

¹ The italics have been inserted by the Author.

PERSONAL AND OTHER NOTES.

(The Editor will be pleased to receive notices of appointments, etc., for publication in this column.)

Sir William Tilden has been elected a Corresponding Member of the Imperial Academy of Sciences, St. Petersburg.

The Right Hon. Sir Henry Roscoe celebrated his eightieth birthday on Tuesday, January 7th, at his country house, Woodcote Lodge, West Horsley.

His former students and friends having decided to commemorate the occasion by the presentation of his bust to the Chemical Society of London as a tribute of appreciation of his long life and work, a representative deputation

visited Sir Henry on that day to convey to him the congratulations of his former students and to acquaint him with their proposal for the commemoration of his birthday. The deputation consisted of Sir Edward Thorpe, C.B., F.R.S., who acted as Chairman; Professor Smithells, F.R.S.; Professor Bedson; Dr. Charles A. Keane; Professor Harden, F.R.S.; Professor Crossley, F.R.S.; Mr. E. J. Bevan and Mr. Watson Smith.

A congratulatory address was presented, in which reference was made to Sir Henry's continued and successful services to chemistry, and to the large debt of thanks that was owed to him by his pupils, his science, and his country. It was pointed out that, although it was twenty-seven years since he resigned the Chair of Chemistry at Owens College, his influence as their teacher and friend had continued, and that amongst his former pupils there were many who, thanks to the teaching they had received at his hands, had been enabled to contribute to the advancement of science.

By the will of the late Professor M. Loeb, of New York University, the following bequests are made to scientific and educational societies. Subject to Mrs. Loeb's life interest, £100,000 is bequeathed to the Harvard University, £500 is bequeathed to the National Academy of Sciences, and £500 is left to the American Chemical Society.

Nature reports that the following prize awards in chemistry have been awarded by the Paris Academy of Sciences:—The Jecker Prize to M. Bourquelot, for his work on the chemistry of plants and plant ferments; the Montyon Prize (unhealthy trades) to Paul Adam, for his work on the reduction of nuisances in the manufacture of superphosphate and his improvements in the storage of petrol and other dangerously inflammable liquids; the Cahours Prize between Mme. Ramart-Lucas, Paul Clausmann, and M. Ostwald; the La Caze Prize (chemistry) to M. Urbain, for his researches on the rare earths.

An advisory council for the Science Museum has been recently formed by the President of the Board of Education. This council has been appointed for the purpose of advising the Board on questions of general policy. The following are the first members of the council:—Sir Hugh Bell, Bart. (Chairman); Dr. J. J. Dobbie, F.R.S., Sir Archibald Geikie, K.C.B., Sir Alfred Keogh, K.C.B., Sir William Ramsay, K.C.B., Rt. Hon. Sir Henry E. Roscoe, F.R.S., Mr. E. B. Ellington, Dr. R. T. Glazebrook, F.R.S., Sir Maurice Fitzmaurice, C.M.G., Sir William White, F.R.S., Mr. R. Elliott Cooper, C.E., the Rt. Hon. Sir William Mather, and Mr. W. Duddell, F.R.S.

Professor R. M. Burrows, Professor of Greek in the University of Manchester, has been appointed Principal of King's College, vice Dr. Headlam, resigned.

We regret to announce the sudden death of Mr. Arthur C. Claudet, A.R.S.M., F.I.C., which took place on the night of January 17th, following an attack of double pneumonia.

CORRESPONDENCE.

(The Editor will be pleased to publish letters dealing with subjects which may be of general interest.)

NOTES ON CHEMICAL ENGINEERING.

By J. W. HINCHLEY, A.R.S.M., WH.Sc.

CHAPTER I.—Continued.

SIZE-REDUCTION OF SOLID MATERIALS.

ROLLS for crushing, in common use, vary in diameter from 9 ins. to 3½ ft. With a given diameter the width of the rolls is determined by several practical considerations. Narrow rolls are more easily kept in order, and produce smaller variations of stress in the frames, and consequently less frictional losses; in addition, they can be run at a higher speed, but one must bear in mind that after exceeding the economic speed no advantage is gained. Taking all the factors into consideration, a width of 10 ins. seems to be satisfactory for most conditions.

Although with large rolls the output and range of reduction is greater than with small rolls, the use of two pairs of small rolls above each other in the same frame is generally more economical, both in first cost and in use, than performing the reduction in one operation with large rolls. In practice, there appears to be no economic advantage in using rolls over 24 ins. diameter.

Although true crushing conditions are obtained by running both rolls at the same speed, better conditions of wear are secured by running one roll 1% faster than the other; the faster roll is also best driven by means of a smaller pulley and belt, so that slip may occur rather than excessive grinding of the roll shell.

Although the economic speed given approximately by the formula previously mentioned ($S = 1,000 - 300 \log d$) is the best, speeds much lower than this are usually found in practice. It may be mentioned that slow running always increases the proportion of fines and dust. Such slow speeds are usually due to faulty mechanical arrangements, defective foundations, or lack of interest in obtaining the highest efficiency.

Rolls are usually made in two parts, viz., a roll centre and a roll shell. The roll shells are trued as they wear and replaced when worn out. They are often bored taper and held on the centre by means of draw bolts; another, but less satisfactory method of fixing them to the centre consists in using wooden wedges, internal key-like projections on the shell fitting into key-ways in the centre; in this case the shells are not bored; occasionally shells are built up in sections, each section being held by two bolts. Chilled cast iron or cast steel are the most efficient materials for shells, although manganese steel or steel forgings are more durable.

The simplest means of truing shells consists in traversing an emery wheel across them every other day or when the amount of uneven wear becomes troublesome. A simple fitting can generally be provided on the roll housings for this purpose.

The sides of the hopper are best placed outside the edges of the rolls, so that an even feed causes the whole faces of the rolls to wear evenly. In any case an even feeding arrangement is most essential for the best results.

The springs on the bearings of the rolls should only come into play on the journals of the rolls when accidentally large material or metal enters the mill. If the springs are continually in action, the power for crushing is increased, but the wear and tear of the journals produces serious items of renewals.

When even crushing to a definite size is desirable with a minimum production of smalls, transverse grooves are provided in the rolls to reduce grinding action to a minimum. Longitudinal grooves may also be cut so as to form pyramidal teeth. Materials such as bones, coke, ice, resin, crystals, etc., may be reduced in such mills with a minimum production of dust.

Such rolls are often mounted vertically, some-

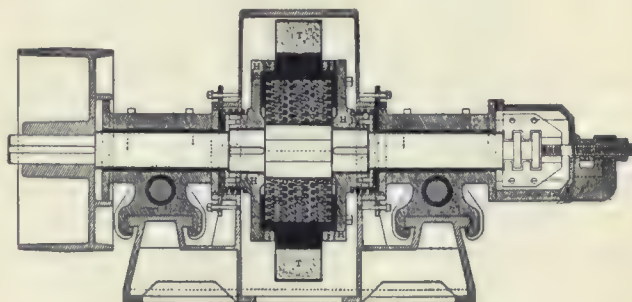


Fig 5

times with five or six in one housing, for the crushing of seeds, canes, etc.

With standard limestone the amount of material crushed from 1½ ins. diameter to ¼ in. diameter is approximately ½ ton per h.p.-hour. With such a material, when running 24-in. rolls at a peripheral speed of from 200 to 250 ft. per minute, the horse power required would be .025 diameter of rolls multiplied by their width (both in inches).

Fine Crushing Machines.—Some of the most successful fine size-reduction machines depend mainly on the crushing principle. Among the best are centrifugal rolls (Fig. 5). These rolls differ from ordinary rolls by the provision of weights and springs between the roll centres and the shell with provision for radial movement only of the shells with respect to their centres. Such rolls are provided with rigid but adjustable bearings, and the crushing surfaces are set closely together. Unlike ordinary crushing rolls which have an economic speed, centrifugal rolls give an output in proportion to their

speed, the limit of output being mainly a question of wear. Both rolls are usually driven by the same belt, and in spite of the enormous forces involved, on account of their easy action and the absence of shock, comparatively small pulleys are required. The speed must be adjusted to the character of the material to give the minimum cost of working.

There are many modifications of rolls for fine crushing in which an internal roll or ring is used. In

is driven, in others the axles carrying the rolls, scrapers being fitted in both cases to move the materials into the path of the rolls. Such mills are usually worked discontinuously, the materials being charged and discharged at convenient intervals. When working such pans continuously steel grids are provided through which the material passes as it becomes reduced. When used for crushing clay, holes of from $\frac{1}{4}$ -in. to $\frac{1}{2}$ in. are provided through which the material is forced. Where heating must be avoided, as in gunpowder work, the rolls are always supported out of contact with the pan so that

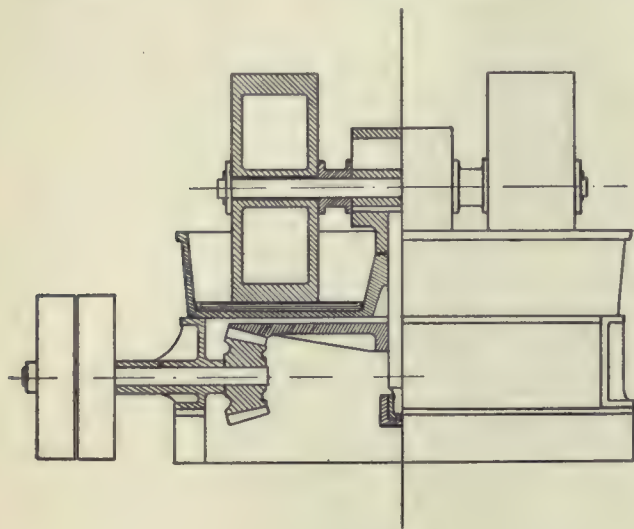


Fig 6

the Sturtevant ring-roll mill the ring is rotated vertically, and a series of stationary convex rollers are pressed by springs against the internal concave grinding surface of the ring. The grinding ring, which is renewable, rotates truly at a peripheral speed of about 650 ft. per minute, the pressure between each roll and ring being about 10 tons. The material is delivered on the concave face of the ring and remains there by centripetal force until crushed off both sides by the action of the convex rolls. On account of the freedom from grinding action, the wear of the rolls and ring is remarkably small, but the product must be sifted and the coarse material returned, entailing another operation.

In the Griffin (1 roll), Bradley (3 roll) and Huntingdon (4 roll) mills, the ring is stationary, and the spindles carrying the roll or rolls are rotated so that the working pressure is obtained entirely by centripetal force. On this account their action is not so smooth as that of the ring-roll mill, and it is very much affected by alterations in speed. In such mills, if particular attention is paid to maintaining well finished, well lubricated, and grit-proof bearings with true wearing parts, the cost of reduction may be kept very low, but they do not give satisfaction for the very finest class of size-reduction without first-class supervision.

A common type of crushing mill, of general application, is the edge runner mill (Fig. 6), of which the ordinary mortar mill is a common type. It consists of one, two or three heavy rolls of cast iron or stone which roll round a pan containing the materials to be crushed. In some machines the pan

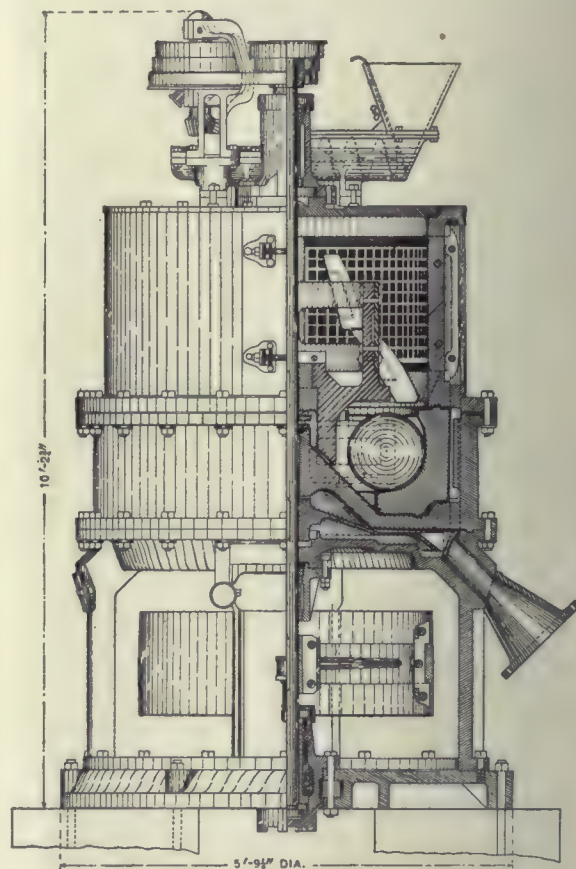


Fig 7

crushing only takes place when the pan is covered to a definite depth with material. Since the crushing pressure is limited by the weight of the rolls, edge runner mills are not suitable for very hard materials unless the fed material is small in size. A high-class mill with two rolls, 4-ft. diameter and 8-in. face, each weighing 1 ton, driven at 40 revolutions per minute, will be capable of crushing 4 tons of standard limestone per hour from $\frac{1}{4}$ in. size to .012 in.; an ordinary mill under ordinary conditions has about a quarter of this capacity.

Although a considerable amount of grinding action takes place in the edge runner mill, it is not suitable for very fine reduction, but is very popular where the material may be left granular. Sometimes the rolls are grooved for dealing with special

materials. For reducing seeds, clay, chalk, roasted products, they are slow but satisfactory.

A large number of fine crushing mills are made in which one or more balls are made to roll in a horizontal ball race or grinding ring. Some of these mills are capable of producing at one operation a product equal in fineness to standard cement. One of the best is the Fuller Mill (Fig. 7). In this mill a number of balls are rapidly driven round the crushing ring with a speed at its surface of about 1,800 ft. per minute. The finely crushed product is raised as a cloud, and by the agitation of the air is projected through the screens seen in the upper part of the mill. Any coarse material falls back again to be re-crushed.

For the reduction in such mills of 1 ton per hour of standard limestone from $\frac{1}{4}$ in. size to the fineness of standard cement (not more than 18% retained on a 180-mesh sieve, and not more than 3% on a 76-mesh sieve) 10 to 12 h.p. is required.

In recent years ball mills and tube mills have become very popular for fine reduction on account of their simplicity of construction, ease of working, absence of delicate parts, freedom from breakdown, and low cost of upkeep.

Such mills consist of a rotating chamber containing balls which crush the material as they fall or roll in its interior. The product is very fine, fairly even, and may be produced so as to need no sifting. A simple type of such mills consists of a stoneware or biscuit porcelain jar which is mounted in a frame for rotation about its axis of symmetry. The jar is half filled with flint pebbles or porcelain balls 2 ins. diameter, and sufficient to more than fill the voids between the balls by about 10%. The jar is closed and rotated on its axis at a peripheral speed of about 160 ft. per minute for a period long enough to give the required reduction. For reducing and mixing small quantities of chemical products such mills are most useful, and since the cost of jars is small, cleaning up and its resultant loss may be avoided by stocking one jar for each product. Ovoid pebbles appear to give better results than round ones, which would seem to show that the grinding is more important than the crushing effect.

For large outputs steel drums lined with porcelain bricks or quartzite blocks are used with flint pebbles of 3 to 5 ins. diameter. For reducing lumps to dry powders, and at the same time associating the powder with small quantities of liquid, these mills are most satisfactory, and are used for disinfecting powders, tooth-powders and materials for plastic compositions, etc.

For large outputs and continuous working the ball mill with screens or the tube mill are most popular.

In the ball mill with screens (Fig. 8) the drum is formed by a series of hard steel grinding plates arranged in steps as shown. As the material is crushed it falls through the perforations in these plates and is sifted by the circular check sieve and finally by the outer fine sieves. The material rejected by these screens is lifted and falls through the gaps between adjacent grinding plates and into

the crushing space again. Such a mill usually gives a little over half the output of the Fuller Mill per h.p. per hour. As a rule this type of mill is only used for the preliminary grinding, its product being delivered to a tube mill for further reduction.

The tube mill is the most popular mill for fine crushing, and consists of a rotating steel tube, those in common use being from 10 to 30 ft. long and 3 to 6 ft. in diameter, lined with cast steel or chilled cast iron plates or quartzite blocks and charged with flint pebbles or steel balls of from 3 to 5 ins. diameter.

The material, which is reduced to at least $\frac{3}{4}$ in. size, is fed in through one of the hollow trunnions and is delivered at the opposite trunnion. The rate of feed determines the rate of delivery and the amount of crushing accomplished. The feed is generally arranged with a worm, but there are other devices



Fig. 8

for both feed and delivery which are doubtful improvements on the simple type.

The amount of power required is rather great if the whole of the reduction is accomplished in one operation, and on this account it is becoming common to pass the product through an air separator and return the coarse material for further reduction.

Davidson's rule for the amount of pebbles in a tube mill is $W = 44M$ lbs., where M is the volume of the tube in cubic feet. The number of revolutions at which the tube should be driven = $\frac{200}{\sqrt{D}}$

where D is the diameter in inches; and the horsepower required = $.15 M$. If the charge of flint pebbles is greater or less than that given by Davidson, then the power required will be greater or less in proportion. As little as $1\frac{1}{2}\%$ moisture is usually sufficient to upset the good working of all these fine crushing machines. On the other hand, such machines work excellently with a considerable amount of water (40% or so).

(To be continued.)

REVIEWS OF BOOKS.

"THE CHEMICAL CONSTITUTION OF THE PROTEINS," Part I. Edited by R. H. A. Plimmer and F. G. Hopkins. LONGMANS, GREEN & Co., London, 1912. Second Edition. Pages 188 + x, including Bibliography and Index. Divided into two Sections, with Diagrams. Price 5/6 net.

The second edition which appears after a three years interval, includes an account of the work which has been published during that time with special reference to that of Abderhalden and Osborne. The first part of the second edition is devoted to analysis, and this volume is indispensable to all those who wish to keep themselves in touch with developments in this direction. The work is divided into two sections dealing respectively with the chemical composition of the protein molecule, and the constitution of the units, or the synthesis of the amino acids, and also includes a general bibliography which is conveniently divided into sections. We have nothing but praise for this work.

"TREATISE ON GENERAL AND INDUSTRIAL INORGANIC CHEMISTRY." By Ettore Molinari. Translated by Ernest Feilmann. J. & A. CHURCHILL, London, 1912. Pages 704 + x, including Index, with 280 Illustrations. Price 21/- net.

The development of the Italian school of Chemistry, and more especially the engineering side of this science, is well exemplified in this work by one of its leading exponents. It will be found to contain much information in its 704 pages, which is of an instructive and valuable nature. The actual details of manufacture naturally deal in greater detail with such industrial developments as are chiefly met with in that country, and the statistics given in connection with certain manufactures are of great interest to the student, as they indicate the progressive nature of the industries dealt with. The possible influence of local conditions upon an industry are also discussed.

On the theoretical side the author's conclusions are in some cases unusual, and attention has been drawn to this by the translator. The modern developments in Italy are of a very thorough nature, and it is likely in the future, that under favourable conditions, they may assume world-wide importance. The translation of this leading work is therefore most opportune, and will be found of great interest to all those connected with chemical affairs in their widest aspect.

"ACHIEVEMENTS OF CHEMICAL SCIENCE." By James C. Philip. MACMILLAN & Co., London, 1913. Pages 217 + vi. Chapters XIV., with 43 Illustrations. Price 1/6.

This small volume is the first in a series of "Readable Books on Natural Knowledge." It contains in a condensed form, and in fourteen short chapters, a great deal of information, concerning such matters as the problem of combustion, source

of power, chemistry and the safety of human life, raw materials, refuse, and by-products.

The results obtained by synthetic chemistry and the general progress in scientific and technical chemistry are also dealt with in such a way that they are immediately brought to the notice of the general reader.

This work indicates in general language the extraordinary advance which has taken place in the science of chemistry, and is calculated to stimulate a more general interest in this subject. The subject matter is certainly presented in such a form that it fully conforms to the title of the series it is published under.

"MODERN COPPER SMELTING." By Donald M. Levy. CHARLES GRIFFEN & Co., LTD., London, 1912. Pages 259 + vi, including Index. Divided into IX. Lectures, including 76 Illustrations, with Frontispiece. Price 10/6 net.

This text-book is based on a series of lectures delivered at the Birmingham University. It deals with the history of copper and its various uses as a metal and alloy; with modern copper-smelting practice, also in detail with reverberatory smelting and blast-furnace practice. The Bessemerising of copper *matte*s and the purification of crude copper is also dealt with at some length. The book is well illustrated and the system of giving references at the end of each chapter to the standard works on the subject in the same is to be commended in a work of this nature.

There can be little doubt but that this work serves a very useful purpose, that it is up-to-date in every respect, and will appeal to all those who use this metal or are engaged in the actual manufacture of copper or its alloys.

"THE ANALYST'S LABORATORY COMPANION." By Alfred E. Johnson. Fourth Edition. J. & A. CHURCHILL, London, 1912. Pages 161 + vi, including Index. Price 6/6 net.

The success of this work is seen in the fact that it has been found necessary to print a fourth edition, which is based on the International Atomic Weights of 1912. This edition deals with, among other subjects, logarithmic tables, melting points, gravimetric and volumetric factors, table of reciprocals, indirect analysis, percentage composition of commonly occurring compounds, sp.g. tables, and a mass of other general data which is required in the laboratory. For its size it is remarkably complete, and the index is such that it allows a rapid reference to the desired subject.

"A TEXT-BOOK OF PRACTICAL CHEMISTRY FOR TECHNICAL INSTITUTES." By A. E. Dunstan and F. B. Thole. Pages 331 + viii, including Appendices and Index. Chapters XVIII., with numerous Diagrams. METHUEN & Co., LTD., London, 1911. Price 3/6.

This work, which emanates from the East Ham Technical College, is intended to combine in one

work the information which it is claimed the student of a technical college or institute may require.

It is essentially a text-book of practical chemistry, and starts off with the so-called dry tests. An interesting feature is the inclusion of a chapter dealing with tests for the "rare" elements. The sections devoted to volumetric and gravimetric analysis are short, but are well considered. The same remark applies to the section on simple gasometry. The chapter on "common operations" is also of distinct value to the student, and the one on physico-chemical determinations will also give him a general idea as to their nature. The work shows evidence of careful production, and may be said to well satisfy the conditions which have called for its publication.

"WHO'S WHO IN SCIENCE, INTERNATIONAL, 1913."

Edited by H. H. Stephenson. J. & A. CHURCHILL, London, 1913. Pages, 569 + ix, including Classified Index and Frontispiece. Price 8/- net.

THE second year's issue of this annual has materially increased in size, and now includes a new section dealing with the World's Scientific Societies and their publications, which runs to ninety-one pages. The biographies, which are also greatly extended in number, run to 440 pages, and include practically all the leading members of the scientific professions. A classified index of the different sections of science and countries of residence is also given. It may be claimed with justice that this work contains information in a condensed form which is unobtainable elsewhere.

BOOKS RECEIVED.

"A History of Chemistry from the Earliest Times till the Present Day," by the late James Campbell Brown. J. & A. Churchill, London, 1913. Pages 543 + xxv, including 106 Illustrations and Frontispiece. Chapters L., including Index. Price 10/6 net.

"Practical Measurements in Radio-Activity," by W. Makower and H. Geiger. Longmans, Green & Co., London, 1912. Pages 151 + vi, including Appendices and Index. Chapters IX., with 61 Illustrations. Price 5/- net.

"Notes on Chemical Research," by W. P. Dreaper. J. & A. Churchill, London, 1913. Pages 68 + x, including Contents. Chapters VII., with a Frontispiece. Price 2/6 net.

"Who's Who in Science, International, 1913." Edited by H. H. Stephenson. J. & A. Churchill, London, 1913. Pages 569 + ix, including Classified Index and Frontispiece. Price 8/- net.

"Industrial and Manufacturing Chemistry" (Organic). Edited by Geoffrey Martin. Crosby Lockwood and Son, London, 1913. Pages 726 + viii, including Appendix and Indexes. Divided into xxiii. Sections, with 249 Illustrations. Price 21/- net.

"A Study of the Salinity of the Surface Water in the North Pacific Ocean and in the Adjacent Enclosed Seas," by A. H. Clark, Smithsonian Institution, Washington, U.S.A., 1912. Pages 33.

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NEW METHODS OF ANALYSIS.

EXAMINATION OF COMMERCIAL CASEIN.¹

By W. HOEPFNER and H. BURMESITER.

To obtain a good idea of the commercial value of a casein it is necessary to consider, in addition to its chemical composition, its physical properties. Of the best technical casein it is required that it should be produced in establishments observing the greatest cleanliness and care, from fresh milk, by acidulation, that it is well washed and dried, that it presents, not a dirty yellow, but a bright yellow appearance and shows no mechanical impurities. The odour of good casein should be clean, not musty or rancid, and should reveal no trace of cheesiness. On treatment with ammonia, after standing several hours, there should remain no undissolved solid particles, rather the entire body should form a clear solution, of tough, viscous consistence. Taking these points into consideration, the process of analysing technical casein should proceed as follows:—

Proportion of Moisture.—Five gms. are weighed in a nickel dish and dried at 212° to 221° F., until unvarying weight is attained. Heating beyond this temperature is to be avoided, because browning of the substance is attended with oxidation processes that affect the result.

Determination of Fat.—With the aid of the Soxhlet apparatus, a certain quantity is extracted with alcohol and ether, the solvent evaporated and the residue weighed.

Determination of Ash.—Two to 3 gms. of the casein, finely pulverized, are weighed out in a quartz dish, carefully incinerated and extracted with water. The residue is moistened with nitrate of ammonia solution, burned until white, the watery extract evaporated to dryness at 212° F., and weighed.

With the aid of the ash determination, the presence of acids and fermenting casein can be ascertained with reasonable exactness. Acid casein is difficult of incineration and shows, as a rule, but little ash. Fermenting casein, on the other hand, burns quickly and shows a much larger proportion of ash. It is customary to allow to technically acid casein a proportion of at most 6% of ash; fermenting casein shows a proportion of 5 to 8.5%.

Determination of Free Acid.—Ten gms. of casein are shaken together with 100 c.c. of water, filtered, to 50 c.c. of the filtrate a few drops of phenolphthalein are added and titrated with tenth normal potash until a red colour is produced. With this process a well washed casein gives but a small portion of acid to the water; the technical product, especially if stored for a long time, always gives a weak acid reaction. The conditions of working must always be the same, period of shaking and temperature must always be alike. For comparative purposes, casein of a known degree of purity may be employed.

Determination of Solubility.—This is of particular importance, for, in the first place, we can by this means detect the intentional or accidental presence of sand, and are moreover enabled to distinguish between old, long stored and fresh goods. Ten gms. of the air-dried substance are weighed in a beaker, 50 c.c. of water poured over it and

¹ *Chemiker Zeitung*, through *Paper*, December 4, 1912.

1 to 2 c.c. of 33% ammonia added. After the mixture has been allowed to stand for a few hours, it is heated, if no solution has occurred, to 86° F. Pure casein swells and produces a tough slimy solution of transparent character. Casein that has been stored a long time is cloudy when dissolved, and the same applies to that which has been dried at too high a temperature. Sand and other impurities settle to the bottom. To determine these quantitatively, 1 gm. of casein is dissolved in 10 drops of ammonia and 25 c.c. of water; the precipitate settles and is washed out by decantation. By boiling the residue with dilute hydrochloric acid any sand that may be present is separated from organic impurities, starch, etc., and the residue is collected on a weighed filter or incinerated in a tared platinum dish. Organic admixtures, as starch, etc., may be identified under the microscope.

The determination of solubility in the presence of borax is effected by adding pulverised borax to the mixture of casein and water until the solution is effected. The result obtained is the same as with the ammonia test.

These processes of testing furnish an idea as to the value of the casein, not only for sizing paper, but as to its availability for use in the preparation of coating colours for chromo-art printing and similar purposes.

COMMERCIAL AND GENERAL NOTES.

Resumption of Camphor Shipments Probable.

Chinese newspapers report that the number of camphor trees in South China has been found far greater than had been considered, and it is generally thought that with settled conditions in the country, there will be a notable increase in camphor exports from southern ports.

On the other hand, reports from Japan indicate that the supply of camphor trees in Formosa has been found much less extensive than anticipated, and a restriction has been placed upon the output of camphor. At present there is practically no trade out of Hongkong in this article, whereas a few years ago it was exported in large quantities.

The Formosa, Chinese or Japanese camphor—the commercial camphor of to-day—is by far the most important variety. It is made by boiling chips of the camphor laurel, or *Cinnamomum camphora*. This tree is found in the interior of the island of Formosa, in Japan, and throughout Central China. It is also found in Upper Burma and the Shan States, but no effort has been made to cultivate the tree beyond some experiments of the Government forest service.

New Sources of Paper.

In view of the search for new paper-making materials which is going on in several parts of the world, an account in No. 9, 1912, of the Kew Bulletin of *Hedychium coronarium*, Koen., and allies, is interesting. The plant, a member of the natural order Zingiberaceæ, is a native of India, being distributed from the Himalayas to Ceylon and Malacca. It is also found in the West Indies, New Zealand, and elsewhere, and it covers large tracts of swamps in Brazil. Experiments have been made with specimens sent from

San Paulo, and papers of exceptional tensile strength, exceeding that of Manila paper, have been produced from the fibre. Owing to a semi-gelatinous constituent, the new paper is said to be practically "natural parchment." Besides possessing self-sizing qualities, the fibre is capable of being worked very quickly on the paper-making machine.

Artificial Silk in Germany.

The annual report just issued by the German Imperial Testing Department states that quite a number of samples of defective artificial silk were received during the past year for examination. The faults in the material took the form of chalky-looking places which were without lustre and very tender. In all cases the goods had been produced by the gun-cotton process. The defects were traced to the presence of free sulphuric acid, due to the decomposition during storage of cellulose sulphate compounds formed in the process of manufacture. A number of apparently pure silk goods were also tested in the laboratories for artificial silk, and in several instances this was found to be present in a large proportion. The mixture is stated to have been very difficult to distinguish from pure silk by mere visual examination even by experts, the adulteration having been made during the throwing operation by doubling fibres of artificial silk along with those of the natural silk, and the pieces woven from the yarn so produced.

Spirit Distillation and Sugar Production in Russia.

Two important industries connected with Russian chemistry are spirit distillation and sugar production, both of which are important features in Russian industrial—not to say fiscal—economy. The spirit business yields an immense revenue to the State, and the excise of about 1¼d. per 36 lbs. leviable on the 73,000,000 poods estimated as the annual sugar consumption, it will be seen, also means a considerable income. The chemistry of petroleum is both theoretically and practically well-worked out on the petroleum fields of Baku and Grozny. Seed-oil crushing and refining and soap-making are further important industries in Russia, and tartaric acid is somewhat extensively produced in the wine districts.

An interesting development to be expected in the near future will be the utilisation of fish waste. At present no use is made of this, but, instead of being allowed to defile the country's waters, it is intended to be turned to commercial account.

Progress of the German Chemical Industry.

According to an article in the *Berliner Börsen Courier*, the German chemical industry has attained an unassailable position. The exporting firms have succeeded in securing such a firm footing in the world's markets, that even altered economic conditions have no terror for them. The total value of production has shown a considerable increase last year, amounting to some 675,820,000 marks, compared with 622,140,000 marks in 1911.

The Balkan troubles have not had as much effect on the chemical exports as had been expected, for although certain acids and salts were exported in diminished quantities on account of the war, there has been an increase in the exportation of inflammable goods and pharmaceutical products, due to the consumption for military purposes.

A branch of the German chemical industry which has prospered greatly during recent years is the manufacture of colours and aniline dyes. The export of these goods has reached enormous proportions, and the value of aniline

dyes alone, exported last year, amounted to over 109 million marks.

Germany's foreign trade in fertilisers has doubled within the last five years, and 1912 showed a particularly large gain over 1911.

New Standards for Imported Flavouring Extracts in Canada.

Exporters and makers of flavouring extracts for the Canadian markets will be interested in the new standards promulgated by the Canadian Government. They are as follows:—

1. A flavouring extract intended for the purpose of flavouring food is a solution of correct strength, as herein-after defined, of sapid and odorous principles derived from an aromatic plant with or without its natural colouring matters, and conforms in name to the plant used in its preparation.

2. The usual solvents employed in the preparation are ethyl alcohol, water and glycerine. In the event of any other solvents being used, such solvents shall be harmless to health and their names shall be plainly stated on the label.

3. Solutions of natural or synthetic preparations, such as vanillin, coumarin, benzaldehyde, methyl salicylate or other sapid and odorous compounds, resembling substances found in plants, or identical with these, if harmless to health, may be sold for flavouring purposes, if properly labelled so as to make it quite clear that they are not extracts as above defined; and preferably by the use of the word "artificial" or "imitation."

4. If such extract be fortified or strengthened by having such natural or synthetic preparations as are referred to in the last section added to it, the fact shall be clearly stated on the label; or the word "compound" or "mixture" shall be used to describe it.

5. Lemon flavour is the extract prepared from the lemon peel, or from oil of lemon, and contains, along with more or less of the terpenes of lemon oil, not less than two-tenths (0.2) of 1% of citral derived from oil of lemon.

6. Terpene lemon extract is the flavouring extract prepared as above described, and contains not less than five (5)% of oil of lemon and not less than two-tenths (0.2) of 1% of citral, derived from oil of lemon.

7. Vanilla extract is prepared from vanilla bean with or without sugar or glycerine, and contains in 100 c.cs. the soluble matters from not less than five (5) gms. of the vanilla bean (the dried, cured fruit of *Vanilla planifolia*).

Synthetic Milk.

In consequence of the constant rise of prices of most articles of food which has been going on for some years on the Continent, the question of replacing expensive foods by cheaper ones of the same nutritive value has occupied the minds of many social economists and inventors. German and Austrian scientists have carried on very energetic research work in connection with this problem which resulted in some surprising results.

One of the most interesting achievements in this direction is, undoubtedly, an invention which has created a certain amount of sensation in scientific and commercial circles. The inventor, a professor of hygienics at the University of Klausenburg (Kolozsvár), Dr. v. Rigler, gave a short account of the synthetic milk in a recent issue of the *Illustrierte Zeitung* of Berlin.

"It will be readily understood," says the author, "that a perfect substitute for cow's milk must possess the

full nutritive value of the real article, and yet be much cheaper. Of the three important component parts of milk, protein, fat, and sugar, only the first one is difficult to get. Cheap fat and sugar can be obtained plentifully from different vegetables, but it is not such a simple task to procure cheap protein. To produce this from animal sources would prove too expensive for the purpose in question, and only the different varieties of cereals can, therefore, be considered as available. These furnish not only sufficient protein, but the chemist will find no difficulty in obtaining also pure sugar.

"The protein substance has to be dissolved, and after mixing it with the required quantity of sugar and salts (lime, soda, etc.), the whole has to be emulsified with the vegetable fat. For this purpose a simple apparatus is necessary which produces about 6 litres of vegetable milk. The mixture obtained is white, of a creamy consistency and perfectly sterilised. After cooling it is filled in bottles. Slightly sweeter than cow's milk, it has, nevertheless, an agreeable taste. The nutritive value of the synthetic milk can be regulated according to the wish of the maker. Its composition as made at present for use in local hospitals and sanatoria is as follows: protein 3.1; fat 3.5; sugar 3.4, and salt 0.4%. The experiments which have been made with synthetic milk in feeding about 620 people of different sex and age have proved the entirely harmless nature of the article while its high nutritiousness makes it a valuable foodstuff."

Establishment of a Municipal Chemical Laboratory in Chile.

At Punta Arenas, Chile, a movement is on foot to establish a municipal chemical laboratory. The city authorities are said to favour the project, and the purchase of a complete laboratory equipment will probably shortly be sanctioned. M. L.

Institute of Chemistry Pass List: December—January Examinations.

Of 27 candidates who presented themselves for the Intermediate Examinations, held in Glasgow in December and in London in January, 8 passed: A. L. R. Clarke, B.Sc. (Lond.), G. N. Grinling, C. W. McHugo, H. A. Phillips, H. V. Potter, A. B. Stich, B.Sc. (Glas.), H. E. L. Thomas, and F. D. White. Of 19 candidates who presented themselves for the Final Examination, 15 passed. In the Branch of Mineral Chemistry: C. D. Barber, B.Sc. (Lond.), T. T. F. Cartwright, B.Sc. (Lond.), A.R.C.S. (Lond.), R. M. Doidge, B.Sc. (Lond.), F. M. Potter, B.Sc. (Lond.), A.R.C.S. (Lond.), and J. A. Watson, A.C.G.I. In the Branch of Metallurgical Chemistry: F. G. Conyers. In the Branch of Organic Chemistry: K. C. G. Arbutnot, B.A. (R.U.I.), J. C. Earl, and F. G. Tarn. In the Branch of the Chemistry of Food and Drugs, and of Water: J. W. Flint, B.A. (Cantab.), D. R. Frazer, H. E. Watts, Ph.D. (Zurich), B.Sc. (Lond.). For the Certificate: E. J. Wilson, M.A. (Cantab.), F.I.C. In General Chemistry: B. W. Drinkwater, A.R.S.M., A.R.C.S. (Lond.), and W. C. Ball, M.A. (Oxon.), Sc.D. (T.C.D.).

Glycerine.—The proprietors of a soap factory in Mazatlan, Mexico, are completing the erection of a glycerine extracting plant capable of producing an output of 2,600 tons per annum of soap lyes; the firm expect shortly to be producing 80% crude glycerine.—*Board of Trade Journal*.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.

21059/11. J. T. ARMSTRONG, London, and J. MORDAN, Hughenden. **Solidifying Hydrocarbon Oils.** 23 September, 1911.

This process for the solidification of hydrocarbon oils consists in causing hydrocarbon oil in a finely divided state to come into intimate contact with glue or other binder, whilst the latter is in a liquid or plastic condition and also in a finely divided state, so as to envelop particles of hydrocarbon oil in more or less thin layers of binder. The hydrocarbon oil and binder thus treated, are collected, and the mass hardened. (14 claims; 6 Figs.)

25454/11. P. FRITZSCHE, Recklinghausen. **Sulphur.** 15 November, 1911.

In the production of sulphur from the action on each other of sulphurous acid and sulphuretted hydrogen, the two gases are treated simultaneously or in succession by a liquid in which aluminium hydrate, or an aluminium compound of similar action, is contained in suspension or solution. (6 claims.)

25506/11. E. A. ASHCROFT, London. **Sulphide Ores.** 15 November, 1911.

A process for the treatment of metal-bearing solutions produced by the treatment of sulphide ores or by other means to obtain zinc therefrom consists in adding to a solution of the metals a metal cyanide or cyanamide solid, or in emulsion or in solution, and subsequently heating the mixture with or without pressure, whereby the zinc is obtained in the form of an insoluble compound. (12 claims.)

25532/11. E. KNECHT, Marple; A. PERL and PETER SPENCE & SONS, LTD., Manchester. **Cellulose Solvent.** 16 November, 1911.

A solvent for cellulose is prepared by precipitating finely divided copper from a suitable salt by a soluble reducing agent and in then treating the separated copper, after any desired washing, with an oxidising agent and ammonia in the presence of water. (7 claims.)

26128/11. L. T. WRIGHT, San Francisco. **Treating Pyrites.** 22 November, 1911.

Iron, and, if desired, sulphur are manufactured from bisulphide of iron or other sulphide of iron by heating the bisulphide or other sulphide of iron in an electric furnace. (1 claim.)

27664/11. F. A. BYRNE, Birmingham. **Curing India Rubber.** 9 December, 1911.

Rubber latex or coagulated rubber is subjected to the vapours, as distinct from smoke, produced by the volatilization, as distinct from burning, of the products of the destructive distillation of wood. (2 claims.)

27711/11. C. H. FIELD, London. **Yeast.** 9 December, 1911.

Yeast is brought to a dry or powdery form by adding water and a yeast-food mixture to the yeast; the whole is then allowed to ferment for a limited time, after which the yeast and solids are separated, and a hygroscopic or absorbent substance added to the creamy separated yeast. (2 claims.)

28598/11. W. J. POPE, Cambridge. **Photographic Plates.** 19 December, 1911.

The development of panchromatic plates is facilitated by subjecting the plate between exposure and development to the action of a reagent capable of destroying by chemical change the coloured material which renders the plate panchromatic. (2 claims.)

1269/12. K. ALBERT and L. BEREND, Amöneburg. **Phenols.** 16 January, 1912.

The manufacture of soluble condensation products from phenols and formaldehyde is characterised by the fact that the condensation is effected in the presence of natural resins, oils, fats, waxes, balsams, their free acids, any kind of tar, or mixtures of these substances, as catalytic mediums. (5 claims.)

5429/12. BADISCHE ANILIN AND SODA FABRIK, Ludwigshafen-on-Rhine. **Mono-cyclic Hydrocarbons.** 4 March, 1912.

Partially hydrogenised mono-cyclic hydrocarbons are manufactured by subjecting halogen substitution products of mono-cyclic paraffins, in the condition of vapour, to the action of a compound which will split off halogen hydride either catalytically or by combining with the halogen hydride. (1 claim.)

5430/12. BADISCHE ANILIN AND SODA FABRIK, Ludwigshafen-on-Rhine. **Caoutchouc.** 4 March, 1912.

Products similar to vulcanised caoutchouc are manufactured by vulcanising a caoutchouc-like substance which can be obtained from isoprene, or a homologue thereof, by polymerising it in the presence of oxidised caoutchouc, or in the presence of from about 2 to 5% of the ozonide of isoprene, or of a member of the same homologous series or of the ozonide of a terpene or similar body. (2 claims.)

6683/12. BADISCHE ANILIN AND SODA FABRIK, Ludwigshafen-on-Rhine. **Hydrogen.** 18 March, 1912.

Hydrogen is manufactured by alternately reducing and then oxidising by means of steam solid ferruginous material that has been obtained by allowing molten iron oxide to solidify. (3 claims.)

11776/12. FARBENFABRIKEN VORMALS FRIEDRICH BAYER & Co., Elberfeld. **Sulphur Dyes.** 17 May, 1912.

New sulphur dyes are produced by heating the nitro- or amino-derivatives of perimidine or its derivatives with polysulphides with or without the addition of copper or copper compounds. (2 claims.)

12995/12. B. BORZYKOWSKI, Charlottenberg. **Dyed Cellulose Esters.** 3 June, 1912.

Dyed cellulose esters are produced by treating hydro- or oxy-cellulose with suitable dyes in an acidylising mixture. (1 claim.)

27150/12. N. TESTRUP, London, and T. RIGBY, Dumfries. **Smelting.** 7 September, 1911.

The invention consists in using wet carbonised peat in the form of cakes or briquettes, which are introduced into the furnace with the charge. The gases leaving the furnace are treated for recovery of bye-products they contain. (3 claims.)



THE CHEMICAL WORLD

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"Science moves, but slowly, slowly creeping on from point to point."—TENNYSON.

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MARCH, 1913.

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THE EXPERT WITNESS.

OUR contemporary *Engineering* has recently dealt with the question of the fees of expert witnesses, in view of a statement by the President of the Law Society "that litigation is more and more controlled by questions of costs, and, *inter alia*, by the fees paid to expert witnesses," and of course, of those of learned counsel. Our contemporary rightly inquires whether it is really a fact that the "greed of expert witnesses is responsible for the increased expense of litigation?"

It is at once noticed that the vagueness of the charge possesses a character which appeals to the public mind, and one which it is therefore equally difficult to refute.

This matter concerns chemists as well as engineers. It may therefore be interesting to follow the subject up in greater detail, more especially from the point of view of the chemist. It must be remembered that the ever-increasing complexity of cases which entail the presence of scientific witnesses may, in view of the natural development of science, be considered in any such estimate.

Everyone who has engaged in, or been brought into contact with such work in the courts, at once realises that any ordinary fee is, in the majority of cases, an inadequate remuneration for the time necessarily spent in the preparation of evidence, and more particularly in guarding, in advance, against the prejudice which may be created by an adverse cross-examination, which may possibly take unexpected directions. It is therefore necessary to allow that the expert witness is entitled to remuneration for more than a day's work, apart from any question as to the uncertainty in the day of hearing, which may upset many professional arrangements. As our contemporary states "in these circumstances what would be regarded as exorbitant fees for an ordinary witness would be but fair remuneration for the expert." It will be remembered that the result in such cases often turns on expert evidence.

As regards the actual fees themselves, these are known to amount to as much as fifty guineas a day in some cases, and there is no doubt but that such

figures have equally applied to chemical experts of standing, when giving evidence in the High Court. It must be remembered that scientific witnesses are only called in a small proportion of cases, and often where expense is of no particular object to either party, and such fees and expenses are a mere bagatelle when compared with the issues at stake.

Under these conditions our contemporary naturally asks the President of the Law Society by what right he inveighs against any other professional man for charging such fees as his client can afford to pay, and points out that if a litigant wishes to have the best expert—that is to say, the one whose testimony is likely to carry most weight with the Court—he must pay a normal price for such services.

The effect of any such action even if it were possible "would disturb the operation of the ordinary law of supply and demand," in order, as he says, "to encourage people to go to law and provide further fees and costs for the legal profession."

No one can say anything against the practice of a solicitor who prepares his client's case for presentation in the best possible manner to the Court; and equally the scientific witness has a right to expect that he shall obtain just remuneration for services which are often rendered at considerable personal inconvenience and obviously in the interests of those parties whom the solicitor, in his turn, equally serves.

Although possibly there may have been in the past a good deal of what might be termed the equivalent of "special pleading" in the case of scientific witnesses, yet it is increasingly difficult for a witness to go into the box and give evidence which does not represent "the truth and the whole truth" so far as he is concerned; and remembering the three classes of experts which were characterised some time ago by the present President of the Local Government Board we may be certain that it can be claimed that chemists have practically confined themselves to a just presentation of the client's case for the benefit and proper consideration of the Court. They have the right to draw attention to this point.

Science and the House of Commons.

Our contemporary *Nature* draws attention to yet another case in which a Departmental Committee has been appointed (in this case by the President of the Board of Agriculture and Fisheries) to deal with an essentially scientific matter, and yet "the Committee does not contain a scientific man." Also that, from the nature of the subject, it is unlikely that its members can acquire second-hand, from expert evidence, the necessary knowledge of the "inwardness" of the subject in hand "which can alone render their advice to the Board of permanent value."

The authorities are under present conditions impervious to outside criticism, and no alteration in the present state of affairs is possible, until such matters are ventilated and driven home in the House of Commons itself.

In this respect it is interesting to note that the present House of Commons, with a membership of 670, has a constitution, according to a recent investigation, which shows the following figures:—

Lawyers (barristers and solicitors) ..	I37
Men of business	I74
Miners	21
Newspaper proprietors	11
Soldiers	40
Sailors	2
Doctors	8
Chemist	1
Engineers	12
Educational	15

It may, therefore, be assumed that Science in a general sense is already represented in the House of Commons by twenty-one members (say 3%) who, while elected on a purely political basis, have a knowledge of scientific principles, although it may be argued that its use is not realised in a useful manner under the present system.

It would be of advantage, if by arrangement or negotiation, the scientific interest could be strengthened by the inclusion of even an extra ten members, who would offer themselves as party members, but, at the same time, emphasise in their selection and otherwise the fact that the scientific spirit must be behind all legislation.

This definite step towards the recognition of Science in the House of Commons is one which we believe must somehow or other be brought within the range of practical politics. Concerted action of the right order can hardly fail to achieve this end. It would be a popular movement with the general public; and this would form an argument in its acceptance with the different parties in the House.

Members elected on such lines would naturally see that their influence was exerted in the direction of an increasingly scientific basis of legislation, whenever this was necessary; and the future of any such movement, in a large sense, would naturally depend upon the way this first step was organised and carried through.

Members in the House of Commons holding this link of common interest would probably act as a

general committee, which would be in direct touch with certain outside organisations.

Legislation to-day is nothing more or less than an attempt to regularise progress along lines which are determined by past progress, which has been greatly influenced by Science in its innumerable applications.

We believe the only solution to a serious state of affairs is to be found in the method of direct protest; and trust that after the recent experience which has been meted out to the medical profession through, it is argued, the want of some such specific plan of action, it will soon be realised in the proper quarters that an attempt will have to be made to protect the increasing interests of Science, and make certain that its influence is more directly brought to bear on many important problems which still await solution at the hands of the politician.

Modern Poetry.

Certain indications, which point to a distinct revival in poetry, have an interest which is not confined to the Arts. Such a movement must necessarily influence the trend of modern thought in a more general way. The possibilities of such a movement cannot be over estimated, for the poets have always reflected, if they have not actually been responsible for, any general advance in thought and general culture.

Literature, in its highest sense, is so closely connected with the advance of a nation, that the Voices which sing from the Hills must necessarily be taken as an expression of the thought of the period. A new poet, by the interest which his recent work has evoked, proves once more that even a materialistic age (such as that we are said to live in) has still a lively interest in the possible advent of a new seer who has seemingly the attributes of a poet. If it should turn out, that Mr. Masfield has indeed the true spirit, and can voice the aspirations and thoughts of the present era, the nation is to be congratulated.

Sir Quiller-Couch has pointed out that this writer has the advantage of following such men as Thomas Hardy, who have cleared the air from the reproach of nineteenth century narrowness, which compelled such writers as Tennyson to automatically cloak their ideas in words which would not offend their readers. This shadow has seemingly passed away, and the ground is cleared for a truer expression of things as they are.

It goes without saying that, if such a movement is extended, it must profoundly influence general culture, and supply a healthy experience to those who lead in the progress of modern life. That it will influence scientific thought is beyond question. The implied reproach that Science has killed or suppressed poetical instinct in modern life is seemingly to supply one of those theories which break down in the light of actual experience.

Such a movement may supply that expression to modern thought which many have thought to be wanting of recent years.

THE CHEMISTRY OF THE CELL NUCLEUS.

By PROFESSOR A. HARDEN, D.Sc., F.R.S.

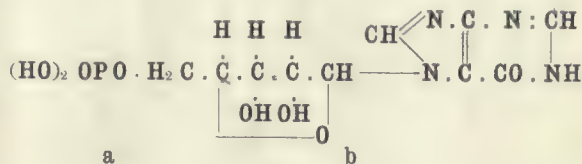
RECENT discussions on the probable nature of the simplest living organisms have drawn renewed attention to the fundamentally important function discharged by the nucleus in the living cell. It is, therefore, of interest to note that during the last two or three years considerable progress has been made in the direction of a clearer understanding of the chemical structure of the material of which the nucleus is mainly composed.

Owing largely to the pioneer work of Kossel and his school, following on the fundamental observations of Miescher, it has become a familiar fact that the nuclear matter of the cell consists chiefly, if not entirely, of compounds of protein with a complex acid termed nucleic acid. These compounds known as nucleoproteins or nucleins according to the proportion of nucleic acid present are readily decomposed by dilute acids or by trypsin yielding a protein, or its products of hydrolysis and nucleic acid.

The protein concerned may be a protamine, a histone or one of the more complex and less basic members of the group, and our knowledge of the special properties of this fraction of the molecule, and more especially of the mode of combination of the protein with the nucleic acid, is still very unsatisfactory. Decided progress has, however, recently been made towards the elucidation of the chemistry of nucleic acid, largely owing to the work of Haiser, Steudel, Neuberg, and especially Levene and Jacobs. The advance has been made by studying the simplest forms of nucleic acid and applying the knowledge thus gained to the examination of the more complex. It has long been recognised that the nucleic acids from whatever source obtained are composed of similar constituent units, which are invariably phosphoric acid, a sugar and one or more bases of the purine or pyrimidine group. The first step in the recent advance consisted in the recognition of the fact that two substances, both of which had been known for some time, viz., the inosinic acid discovered in meat extract by Liebig in 1847, and the guanylic acid prepared from the pancreas by Bang in 1899, are of comparatively simple structure. It has been found that these substances can be hydrolysed in two different ways. In acid solution the purine base is split off and a phosphoric ester of a carbohydrate produced. This interesting substance was found to be a derivative of the pentose, d-ribose, a sugar which had not previously been observed in nature, or for the matter of that, in the laboratory. Of great interest is the fact that the carbohydrate obtained from the two compounds was the same.

Hydrolysis in neutral solution, however, produced quite a different result. The cleavage of the molecule occurred at a different junction, and the

products were phosphoric acid and a non-reducing complex of d-ribose and the purine base. This substance, termed a nucleoside by Levene and Jacobs, on acid hydrolysis yields the base and d-ribose. The general structure of the two acids is thus rendered clear. They consist of a molecule of d-ribose combined on the one hand as an ester with phosphoric acid, and on the other hand probably by the aldehydic carbon atom, with a purine base. The exact details of the position of the phosphoric acid radical in the sugar molecule and of the latter in the purine base molecule are not definitely known, but there is a considerable amount of evidence for the following formula for inosinic acid.

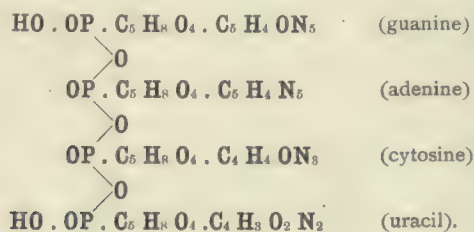


In this case acid hydrolysis produces cleavage at the line *b*, d-ribose-δ-phosphoric acid and hypoxanthine being formed; neutral hydrolysis on the other hand occurs at *a*, yielding phosphoric acid and the nucleoside, inosin, which on further hydrolysis decomposes at *b*, yielding d-ribose and hypoxanthine. Similarly guanylic acid, which yields guanine on hydrolysis in acid solution and the nucleoside, guanosin, in neutral solution, has the formula $\text{H}_2\text{O}_4\text{P} \cdot \text{C}_5\text{H}_8\text{O}_3 \cdot \text{C}_5\text{H}_4\text{ON}_5$.

Turning next to yeast nucleic acid we find a much greater degree of complexity, since no less than four different bases are yielded by acid hydrolysis, viz., the two purine bases, guanine and adenine, and the two pyrimidine bases, cytosine and uracil. The clue to the constitution of this substance is afforded by the fact that hydrolysis in neutral solution also yields, among other products, guanosin identical in every respect with that obtained from guanylic acid. The other products are four molecules of phosphoric acid and three other nucleosides, each consisting of a molecule of the same d-ribose combined with one of the bases adenine, cytosine and uracil. These are derived from groups each resembling guanylic acid in structure, but containing different bases, and to these the name of *nucleotide* has been given.

The general structure of the molecule of yeast nucleic acid is thus made clear. It is made up of four nucleotide groups, each consisting of phosphoric acid, d-ribose and a base. The mode of combination of these groups is still doubtful, but it is effected most probably by anhydride formation between the hydroxyl groups of the phosphoric acid radicals.

A tentative formula for yeast nucleic acid is, therefore, the following:—



The first action of acid is to liberate the four nucleotides, and of these the two containing cytosine and uracil have actually been obtained in this way, whilst the other two are much more easily hydrolysed and have not yet been isolated.

The close analogy which exists between the nucleic acids of yeast and of the animal organs indicates that the chemical structure is also similar. Speaking broadly, this is undoubtedly true, but it is also true that many differences exist. Thus thymus-nucleic acid does not yield a pentose on hydrolysis, but the products of decomposition of a hexose, the carbohydrate itself not having yet been isolated or identified.

Further, it contains thymine instead of uracil, and there are indications that part, at all events, of the sugar is present as a diphosphoric ester. There seem, however, to be only four nucleotide groups concerned, just as in the yeast nucleic acid, and a nucleoside containing guanine and a hexose has already been isolated, so that the general scheme

of structure is similar to, even though not identical with, that of the acid from yeast.

The next question that arises is how this complex molecule of nucleic acid is built up and broken down in the living organism. As regards the first portion of this problem—the synthesis of the acid—nothing is known. A complete battery of hydrolytic enzymes has however been discovered, which enables the organism to decompose nucleic acid, first into the nucleotides (nucleinases), then into phosphoric acid and nucleosides (nucleotidases), and, finally, into carbohydrate and base (nucleosidases), thus following the course of hydrolysis in neutral solution.

Specific enzymes exist for each stage of this process, and these are quite distinct from the digestive enzymes (pepsin, trypsin, erepsin, etc.). They occur in almost all the animal organs, but are absent from the gastric and pancreatic juices. Intestinal juice can take the decomposition as far as the production of nucleosides, but no further. The purine bases thus liberated in the natural metabolism of the cell undergo further enzymatic change, and are in part excreted as uric acid, the remainder being probably completely oxidised.

The presence of such a complex chemical structure in the nucleus, and the provision of an armament of enzymes by which it can be resolved into its constituent units is quite in accordance with what we know of the functional importance of this portion of the cell. Further investigation based on what has already been discovered can hardly fail to lead us appreciably nearer to an understanding of the mechanism of life itself.

THE MILK AND DAIRIES BILL.

By H. DROOP RICHMOND, F.I.C.

ALTHOUGH the Milk and Dairies Bill aims primarily at the amelioration of public health, by the more effective registration of dairies and dairymen; by the inspection of dairies and the examination of cows therein; by the prohibition of the supply of milk where such a supply has caused, or would be likely to cause, infectious diseases, including tuberculosis; by the prevention of the sale of tuberculous milk; by the regulation of the importation of milk, so as to prevent danger to public health arising therefrom; by the issue of regulations for securing the supply of pure and wholesome milk; and by the establishment of milk depôts for the sale of milk specially prepared for infants, there are several questions of chemical interest, which arise from the provisions.

The public official on whom the duties of carrying out the provisions of the Bill are thrust, is the medical officer of health, who is given very wide powers, amounting in some of the clauses to arbitrary powers, for the execution of his duties of inspection or prohibition. Thus he is empowered to make an interim order, prohibiting the supply of milk for ten

days, if he is of opinion that infectious disease is caused, or likely to be caused, by the milk from the dairy against which the order is made, and it may be pointed out that such an order (against which there is no provision for appeal) would be sufficient to ruin the proprietor of the dairy. Yet, with these wide powers, not only is there no uniform method of procedure prescribed, one opinion alone being sufficient, but, in various ways, the medical officer of health is obliged to delegate a portion of his duties to other officials.

This is clearly shown by Clause 2 (1), which permits him, *if accompanied by a veterinary inspector or some other properly qualified veterinary surgeon*, to inspect the cattle. It is obvious that if the medical officer of health is of opinion that infectious disease is caused, or likely to be caused, by any condition of the cattle, such opinion must be based on the opinion of the veterinary inspector. Further, Clause 13 (1) empowers the medical officer of health to take samples of milk obviously for bacteriological examination, and such samples of milk may, under certain conditions, be used for the purpose of

proceedings under the Sale of Food and Drugs Acts. This clause again clearly shows that the medical officer of health is dependent on the opinion of another official, the bacteriologist, and the wording of the Bill clearly contemplates that the bacteriologist, in some cases at least, will be the public analyst. There are numerous districts in which the public analyst has a bacteriological qualification, and in these this provision will work smoothly, except possibly that this official may find that the Bill, when passed into law, thrusts new duties upon him without adequate further remuneration. In other districts it may lead to the public analyst being forced by his authority to carry out the duties of bacteriologist, possibly again without any increase in his remuneration. Or, what is perhaps more likely than the immediately preceding alternative, a bacteriologist may be appointed who is more qualified in bacteriology than chemistry, and the authority appointing him may desire to appoint him also as public analyst, and dispense with the services of the present holder of that appointment.

Local authorities do not always realise that bacteriology is a laboratory science, and that while the chemist who has been trained at laboratory work for many years can, and in numerous instances does, easily qualify as a bacteriologist, the bacteriologist, pure and simple, whose training may have been largely clinical, and who may have had little laboratory experience, will qualify with much greater difficulty in chemistry.

A very important portion of the Bill is Clause 15, which empowers the Local Government Board, after consultation with the Board of Agriculture and Fisheries, to make orders for the purpose of carrying out the Act, and one at least of the matters with respect to which they may make orders, raises important chemical considerations. This is:—

"(f) The prohibition or regulation of the use of colouring matter in milk, and of the addition to milk intended for sale for human consumption of skimmed or separated milk or water or any other substance, and of the sale for human consumption of milk to which such an addition has been made."

It is not quite easy to understand what the framer of this clause had in mind; the first portion is obviously clear, and there is little doubt that the colouring of milk will be prohibited, especially as there will be little serious opposition on the part of the trade. Colouring of milk, as of butter, was in the first instance resorted to, to attain continuity of colour all the year round, and most dairymen would be willing to relinquish the practice, and the expense it entails, provided that their competitors, as well as themselves, were obliged to do the same, and the public would soon be educated to the fact that milk is nearly always white, and would cease to complain of the poverty of milk which was not a rich yellow hue. The prohibition of colouring would, however, lead to an addition to the work of public analysts, *i.e.*, the systematic search for colouring matters in all samples, for which it would be difficult to obtain any further remuneration.

As to the remainder of the section, it is difficult

to grasp exactly the significance. Does it mean that toning down of milk is to be legalised? Does it mean that the intention is that milk should be sold in grades, at prices corresponding, or, at any rate, bearing some relation, to the actual food value? There is naturally a good deal to be said in favour of the latter view; it is certainly anomalous that milk containing 3% of fat should be sold at the same price, and passed equally as genuine milk, as that containing 4% or 5%; this provision, if indeed it is intended, makes for the "authoritative approval of the good, as well as the authoritative condemnation of the bad." While such a regulation might add slightly to administrative difficulties, it would give the purchaser an opportunity either of getting an article at the lowest possible price and of a corresponding quality, or of obtaining a guaranteed quality for which he would naturally pay more.

The last clause which is of a chemical interest is that which abolishes the warranty under the Sale of Food and Drugs Acts in respect to milk, Clause 16, and by the interpretation Clause 24, also in respect to cream. It appears obvious that the words "unless it is contained in a sealed vessel" should be added, for it is unfair to the vendor to expect him to be responsible for the sale of goods over which he has no control. With the addition of these words, the clause would be perfectly satisfactory.

The warranty clause of the Sale of Food and Drugs Acts has probably been productive of more hard swearing, and has more often defeated the ends of justice than any other provision in the Acts, and now that milk can be so rapidly, easily, and cheaply tested, even by comparatively unskilled persons, the abolition of this defence should inflict no real hardship on the vendor, or, at any rate, nothing like the hardship it has inflicted in the past on the giver of the warranty. Under the clause in the Sale of Food and Drugs Acts, the farmer was responsible for milk for many hours after it had passed from his control, to which colouring matter had been added, which had been divided into many portions, without any guarantee that it had been adequately mixed, to which other milk might have been added, and which might have been impoverished, often unwittingly, no doubt, by being allowed to stand, and the cream, naturally separating, being removed; it is obviously time that this defence is abolished.

It is possible also that Clause 18, which provides for the establishment of milk depôts, may also add to the duties of public analysts, as there is no doubt that the control of the milk specially prepared for consumption by infants under two years of age will require a certain amount of chemical work, and it is possible that here, again, local authorities may seek to impose new duties without an adequate increase in remuneration.

By-Product Recovery.—J. E. Christopher recently gave interesting particulars before the Manchester Section of the Society of Chemical Industry of working costs of different processes. He said that 369,000 tons of sulphate of ammonia are produced annually in this country, but only 70,000 tons are used. The use of coke oven gas for municipal purposes at Ghent was also noticed.

THE ACTIVE PRINCIPLES OF ERGOT.

By FRANCIS H. CARR.

ERGOT is the mycelium or spawn of the small fungus *Claviceps purpurea*, which develops in the ovaries of certain grasses. Grain of most kinds is liable to become the host of this fungus, but it develops most largely in rye. As it exhibits alternative means of reproduction, upon the soil and upon the ear of the grass, the agriculturist has found difficulty in excluding the fungus from foodstuffs. Owing to this cause numberless epidemics of the disease known as ergotism have occurred among the races who have fed upon infected rye, the earliest recorded instance of such an outbreak being about 837 A.D. The cause of these visitations was for long shrouded in mystery, and it was not until the close of the seventeenth century that the malady was clearly recognised as an effect of ergot.

Ergot is an exceedingly important therapeutic agent, owing mainly to its property of causing the contraction of the uterus and arresting hæmorrhage. Its acknowledged use for this purpose dates from the beginning of the nineteenth century, but it was employed by midwives long before this time. As far back as 1582, Adam Lonicer, of Frankfurt, mentioned in his writings the use of ergot in hastening labour; and the first reference to ergot was very much earlier even than this. In the second edition of the Sacred Book of the Parsees—the Zendavesta (400 B.C.)—mention is made of a grass which acts upon the uterus.

But a knowledge of the uses of ergot, as of so many other drugs, must have been handed down by oral tradition from a time long antecedent to the earliest records. It is supposed that the Chinese used ergot thousands of years ago, and the "wise women" of the Highlands of Scotland are said to have employed it in very early times.

The chemistry of ergot has received much attention in the past century, but only during the last six years has any real elucidation of the problem resulted. The first careful research was that of Wiggers in 1831. In addition to an oil and resin he isolated from ergot a crystalline wax-like substance—probably the "ergosterine" of later investigators—and a new sugar which has since been shown to be trehalose. He attributed the toxic properties of ergot to the resin and its therapeutic activity to a water-soluble substance. In comparison with the work of many who preceded and followed him, and considering the state of chemical knowledge at the time, the work of Wiggers was remarkable.

The next person whose researches claim our attention is Wenzell, who in 1864 obtained from ergot two alkaloids in a crude condition, ergotine and ecboline. Ten years later Buckheim suggested that the action of ergot is due to the "putrid and septic" substances it contains—a suggestion destined to meet a remarkable degree of confirmation later, but which for a while was obscured by the

brilliant work of Tanret, who in 1875 isolated a pure crystalline alkaloid, ergotinine. This alkaloid, which is well crystallised but does not form crystalline salts, was regarded by its discoverer as the true active principle of ergot. Investigators who followed cast doubts on this view (which has recently been proved incorrect), one reason being that ergotinine and its salts are sparingly soluble in water, and water-soluble extracts were found to be active. Attention accordingly was turned in a new direction. Various acid substances in a partly purified condition were shown by a number of investigators to possess physiological activity, and on that account many claims to the discovery of the active principle were advanced. But this activity, which was really due to adherent alkaloid, proved in practice to be variable; and thus, in the thirty years which followed Tanret's discovery, little obvious progress was made.

In 1906 the alkaloid ergotoxine was isolated by Barger and Carr, and the claim that this substance is the chief active principle peculiar to ergot was established by Barger and Dale. This alkaloid, which has the empirical formula $C_{35}H_{41}O_6N_5$, is amorphous, but forms crystalline salts. It has the somewhat uncommon property in alkaloidal salts of forming colloidal solutions that are readily precipitated on the addition of an ionised acid or its salts. This property, aided by an exceptional tendency to adhere to any accompanying substance, accounts for the activity observed by many investigators in the varied substances for which the claim of active principle has been advanced. Almost simultaneously with the publication of these results Kraft recognised the presence of the alkaloid and rightly suggested that it was a hydrate of Tanret's ergotinine. Later, by crystallising the salts of his base by Barger and Carr's method, Kraft was able to identify his alkaloid with ergotoxine.

The amended empirical formula $C_{35}H_{39}O_5N_5$, ascribed by Barger and Carr to ergotinine, was subsequently accepted by Tanret.

Considerable agreement has also been attained regarding the physiological effects of ergotoxine and ergotinine. In particular, the researches of H. H. Dale have thrown light upon that difficult problem. The production of gangrene in the cock's comb of the domestic fowl has long been recognised as an effect of ergot, and this property is possessed by ergotoxine. It also causes a stimulation of plain muscular tissues, producing a rise of arterial blood pressure and a contraction of the pregnant uterus. Ergotinine, on the other hand, when uncontaminated with ergotoxine, possesses no physiological activity.

Nevertheless, it was pointed out that many ergot preparations possess a physiological action not entirely attributable to ergotoxine; and a further prolonged research by Rieländer, Barger

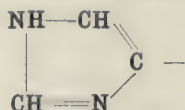
and Dale, Kutscher and others, revealed the presence in ergot preparations of a number of simpler bases derived from amino-acids by the elimination of CO_2 . Such bases are generally formed by putrefaction, and it is to be remembered that as long ago as 1875, Buckheim had suggested that ergot owes its activity to putrefactive products derived from protein. Ergot, being a fungus, is more nearly related to the bacteria than to the higher plants; the formation of these amino bases is, therefore, the more readily to be understood.

The first markedly active base of this class to be obtained from ergot was p. hydroxyphenylethylamine, isolated by Barger and Dale in 1909. The substance named is produced by the action of putrefactive bacteria upon tyrosine (p.-hydroxyphenylaminopropionic acid), an amino-acid occurring frequently both in plants and in animal tissues. Dale found that this base, in common with ergotoxine, caused contraction of the uterus and rise in the blood pressure, but that it differed from ergotoxine in its effect upon the sympathetic functions.

Still the physiologist was unsatisfied that the whole of the useful activity of ergot was accounted for by the two substances in question; for it was observed that some ergot extracts caused tonic contraction of the isolated non-pregnant uterus—a property not possessed by either ergotoxine or p. hydroxyphenylethylamine. The chemist was, therefore, urged to make yet further search, and again success was achieved, for in 1910 β -aminoethylglyoxaline was isolated by Barger and Dale from a preparation of ergot, and was shown to cause contraction of the uterus. This third active principle is of considerable importance, owing to its high potency and its property of causing tonic contraction of the isolated non-pregnant uterus. Almost simultaneously, Kutscher obtained from ergot a very active base which he considered to be closely related to β -aminoethylglyoxaline, though a supposed difference in the physiological action of the two bases led him to regard them as not identical. It was, however, shown later that these differences were due to differences in the animals employed for testing purposes.

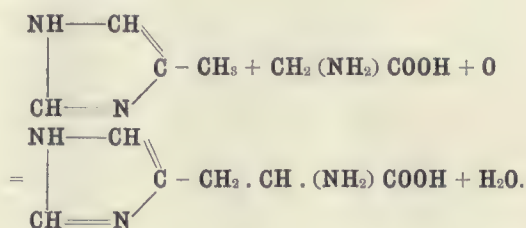
β -Aminoethylglyoxaline bears the same relation to the amino-acid, histidine, that p. hydroxyphenylethylamine does to tyrosine, that is to say, it is derived by the removal of CO_2 . This change may be brought about by putrefactive bacteria. Histidine results from the hydrolysis of certain proteins, some of animal and others of vegetable origin. That its constitution is that of α -amino- β -glyoxaline 4 (or 5)-propionic acid, has been amply confirmed by the recent synthesis by Pyman.

Much interest attaches to the glyoxaline nucleus



contained in this compound as it appears to hold an important place amongst natural products. Its

recognition in naturally occurring compounds was first made in pilocarpine by Jowett and Pinner. It is also present in that large and important class of naturally occurring substances—the purine derivatives. A possible explanation of its formation in the plant economy is afforded by the work of Knoop and Windaus, who showed that glyoxalines are formed when ammonia is added to a cold aqueous solution containing an aldehyde and the mixture is acted upon by light. Certain sugars will thus give methyl-glyoxaline; and it has been suggested that histidine is derived by the condensation of methylglyoxaline with glycocol and simultaneous oxidation:—



Further association of the active compounds derived from ergot with animal bases is brought about by the isolation from ergot by Engeland and Kutscher of yet another base of that class, namely, agmatine, which, according to these authors, has an action on the uterus comparable to that of the bases previously described, but Dale and Laidlaw have since shown that the action of agmatine is comparatively so very weak that it hardly makes any significant contribution to the activity of ergot.

Agmatine $\text{NH}_2 \cdot \text{C}(:\text{NH}) \cdot \text{NH} \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{NH}_2$ was first discovered in herring roe. Its relation to the amino-acid arginine is analogous to that of β -aminoethylglyoxaline to histidine.

Thus we have in ergot four active bases, different in character; three of them are very potent and exercise upon the uterus an action that is of the greatest importance in clinical practice, yet neither of these three bases alone can be regarded as of the same value as a comparable dose of a mixture of them.

Since this account relates only to the usefully active principles of ergot, no reference is here made to the numerous other substances that have been identified in ergot, including several acids and bases, a phytosterol, a sugar, etc.

For much of the early history of ergot given above the author is indebted to the Hunter Memorial Essay by Dr. J. Gordon Sharp in 1910, to which the reader is referred for a much more detailed account of this part of the subject.

A SPECIAL meeting of the Faraday Society will be held in the rooms of the Chemical Society on March 12th. A general discussion will take place on the subject of "Colloids and their Viscosity." Papers will be read by Dr. Wolfgang Ostwald, Drs. H. Freundlich and N. Tshzake, Dr. W. Pauli, Dr. V. Henri, Mr. E. Hatschek, Professor F. G. Donnan, F.R.S., Dr. S. B. Schryver, Professor W. M. Bayliss, F.R.S., and Mr. W. B. Hardy.

INSTITUTE OF CHEMISTRY LECTURE.

MR. W. J. A. BUTTERFIELD, M.A., F.I.C., delivered his second lecture on the "Chemistry in Gasworks" on January 31st, in the Chemical Lecture Theatre of University College (by kind permission of the committee of the College), Professor Raphael Meldola, D.Sc., LL.D., F.R.S. President, in the Chair.

The first of the two lectures had been delivered on December 18th, last and dealt chiefly with the requirements of a public gas supply, the magnitude of operations in the gas industry and the manufacture of gas by the carbonisation of coal and by the carburetted water gas process. In his second lecture Mr. Butterfield first referred to the principles underlying the condensation of crude gas and the extraction of tar from it. The conditions leading to deposition of naphthalene in mains and services were discussed, and an experiment was shown demonstrating the obstructive effect of one-hundredth part of a pound of naphthalene. In dealing with ammonia recovery, the lecturer compared the ordinary washing process with the processes for the direct productions of sulphate of ammonia which are used in connection with recovery coke-ovens, and in a few gas works. The extraction of cyanogen from coal gas by the Beckton or Bueb, the Foulis, and the polysulphide processes was next considered, and the successful introduction of a modification of the latter process by P. E. Williams into London gasworks recorded. Materials for the removal of sulphuretted hydrogen from gas were exhibited and their action described. The sensitiveness of lead acetate paper as a test for the presence of sulphuretted hydrogen was shown to vary inversely with the area of the paper exposed to the gas.

The sulphur impurity remaining in gas after the extraction of sulphuretted hydrogen was considered by the lecturer to be objectionable on account of its destructive action on the metal work of inverted burners and fittings directly exposed to the undiluted products of combustion

of gas. Its relation to the general vitiation of the air of occupied rooms was indicated, and the recent resuscitation in London works of the heated-contract-substance process for the removal of carbon disulphide from coal gas, originally proposed by Dr. A. Vernon Harcourt, about 1870, was referred to. In connection with the by-products of gas manufacture, it was stated that the predominant uses of tar at the present time are for the production of pitch for the supply of the patent-fuel industry of South Wales, and for road construction and treatment. The lecturer said that physical tests of tar and pitch were misleading as to the value of these materials for the latter purpose, because the physical characteristics changed with efflux of time, and the extent and bearing of the changes which would thus occur in tar and pitch could be ascertained only by appropriate chemical examination of them.

Calorimetry of gas was referred to, the Boys and the Junkers calorimeters being shown in action. The lecturer then drew attention to the acceptance practically everywhere except in German-speaking countries, of the Harcourt 10-candle pentane lamp, devised primarily for use in gas-testing, as the reference standard of light for all photometric work. The secondary electric standard lamps were calibrated by comparison with it. The stages in the evolution of the present pentane standard by its inventor were indicated by the exhibition of five earlier pentane standards which Dr. A. Vernon Harcourt had successively devised between the years 1877 and 1897, and had discarded in favour of the present standard which he first described in the latter year. The lecturer stated that he had made comparative tests of the light afforded by about 150 different specimens of the Harcourt 10-candle lamp, and had never found disagreement by more than 0.2%, except in cases where a fault in construction had been found. The Hefner standard of light, which is still generally retained in German-speaking countries, was also shown, and the effects of variations in atmospheric conditions on the light of gas and other flames were indicated.

NOTES OF MEETINGS.

INSTITUTE OF CHEMISTRY.

The 35th Annual General Meeting of the Institute of Chemistry will be held at 30, Bloomsbury Square, London, W.C., on March 3rd, 1913, at 4.30 p.m.

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CHEMICAL SOCIETY.

March 6th, at 8.30 p.m. Ordinary Meeting.

March 14th, at 4 p.m. Annual General Meeting.

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SOCIETY OF CHEMICAL INDUSTRY.

LONDON SECTION:—March 3rd, J. H. Coste, "Notes on Thermometry."

LIVERPOOL SECTION:—March 12th, H. E. Potts, "Some Problems of the Rubber Industry."

MANCHESTER SECTION:—March 7th, T. Stenhouse, "Notes on Coal Tar from Vertical Retorts."

THE ROYAL INSTITUTION.

March 1st, 8th and 15th, Professor Sir J. J. Thomson, O.M., F.R.S., "The Properties and Constitution of the Atom," 3 p.m.

March 3rd, General Meeting at 5 p.m.

March 6th and 13th, Mr. W. B. Hardy, "Surface Energy," at 3 p.m.

March 7th, Mr. C. T. R. Wilson, "Photography of the Paths of Particles Rejected from Atoms," at 9 p.m.

March 14th, Dr. A. E. H. Tutton, "Great Advance in Crystallography," at 9 o'clock.

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INSTITUTION OF CIVIL ENGINEERS.

March 4th, 11th and 18th at 8 p.m. Ordinary Meetings.

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INSTITUTION OF MECHANICAL ENGINEERS.

March 14th. General Meeting at 8 p.m.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

THE FORMATION OF NITRITES.

By J. H. STANSBIE, B.Sc., F.I.C.

It is well known that nitrous acid appears abundantly in solutions resulting from the dissolution of metals in nitric acid. This is particularly the case in the reactions of copper with nitric acid; and as there are two possible nitrites of the metal it was thought that additional information of the general reactions might be obtained by further investigation. For this purpose advantage is taken of the fact that copper and other metals will displace silver from solutions of its salts; and that sulphuric acid will liberate nitrous acid from potassium nitrite in dilute solution.

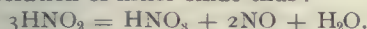
Short tubes of the metals under examination were made from the rolled sheet for the malleable metals, and cast to pattern for the brittle ones.

The solution, which was to contain free nitrous acid, was prepared immediately before use, by adding a measured volume of dilute sulphuric acid to a measured volume of potassium nitrite solution containing 2 gms. of the nitrite per litre.

The change is represented by the equation:



Such a solution may be regarded as practically free from nitric acid in the first instance, although the higher acid is slowly formed by the decomposition of the lower one, with liberation of nitric oxide thus:



The reactions of the metals with nitrous acid in such a solution must then be considered to take place in the presence of small quantities of nitric acid, and also of potassium sulphate. The latter, however, cannot exert much influence except with a metal such as lead that forms an insoluble sulphate which would produce an insoluble film on the surface of the metal and either retard the dissolution or prevent it altogether.

The silver solution was made to contain 1 gm. of the nitrite per litre.

Trials were first made with the solution at rest, but the action was too slow and the results unsatisfactory. The experiments which gave the best results were made with the rotor apparatus shown in Fig. 1, in which A represents a glass tube into the narrow end of which a stout platinum wire is fused; B, a beaker for containing the solutions, and C the moving part of the rotor apparatus. A tube of the metal under examination, supported on the glass tube A, was rotated in the solution for a given time, the solution poured into excess of sodium hydroxide and made up to a measured volume. The metal in the precipitate, and the nitrous acid in the solution were then determined. As a simple method of comparing the results obtained with the theoretical composition, the weight of nitrous acid required to form nitrite with the weight of metal found is calculated and given with each experiment.

Copper and Silver Nitrite.—A copper tube was rotated

for 1½ hours in 100 c.c. of solution containing about 100 mgrs. of silver nitrite, with the following results:

Copper found = 18.4 mgrs.

Nitrous acid found = 27.34 "

Calculated to satisfy $\text{Cu}(\text{NO}_2)_2$ = 27.46 "

Copper and Nitrous Acid.—A copper tube was rotated for 2 hours in 50 c.c. of a solution containing 100 mgrs. of potassium nitrite and 5.3 c.c. of standard sulphuric acid of which 1 c.c. = 10.12 mgrs. H_2SO_4 .

Copper found = 23.5 mgrs.

Nitrous acid = 34.78 "

Calculated to satisfy $\text{Cu}(\text{NO}_2)_2$ = 35.06 "

The solution was known to contain 50.9 mgrs. of nitrous acid at the beginning, so that 16 mgrs. must have undergone decomposition, and this would be equivalent to the gradual appearance of 7 mgrs. of nitric acid in the solution. This, however, does not appear to affect the action of the lower acid to an appreciable extent. It seems clear from these results that the habit of copper is to form cupric nitrite when nitrous acid is in excess; but whether this is so in the presence of excess of nitric acid and of cupric nitrite is still an open question.

Zinc and Silver Nitrite.

—Similar experiments were made with zinc, but sodium carbonate was used to precipitate the metal from the nitrite solution. The reaction may be complicated by the presence of a silver zinc couple, directly silver is deposited on the zinc, but the results show that this does not interfere to a serious extent with the general reaction. The zinc tube was rotated for 1 hour in the solution.

Zinc found = 16.4 mgrs.

Nitrous acid found = 24.53 "

Calculated to satisfy $\text{Zn}(\text{NO}_2)_2$ = 23.71 "

Zinc and Nitrous Acid.—The solution used was similar to that for copper, and the zinc tube was rotated for 2 hours.

Zinc found = 27.0 mgrs.

Nitrous acid found = 42.5 "

Calculated to satisfy $\text{Zn}(\text{NO}_2)_2$ = 39.1 "

The experiments were made to test whether the zinc would react or not with the nitrite and the nitrous acid, as the habit of the metal in the formation of its compounds is well known. The result obtained with the nitrous acid

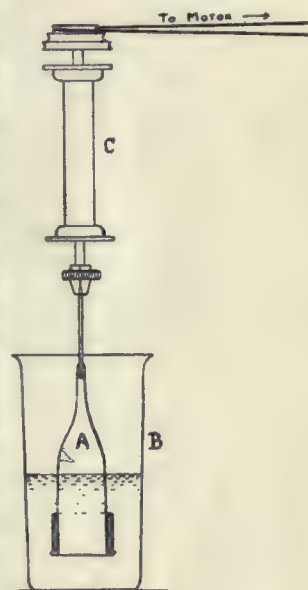


FIG. 1.

seems to indicate that zinc nitrite is more stable than copper nitrite under similar conditions.

Mercury and Silver Nitrite.—A solution containing 200 mgrs. of the nitrite was allowed to stand in contact with excess of mercury for 52 hours. It was then poured into excess of sodium hydroxide and made up to 250 c.c. The clear solution was examined for nitrous acid, and the precipitate for silver and mercury. The silver was weighed as chloride and the mercury as sulphide.

Weight of silver found = 69.8 mgrs.

" mercury found = 48.9 "

" nitrous acid found = 58.1 "

This long exposure had precipitated less than half the silver present, but the proportions of the two metals to the nitrous acid indicate the probable formation of mercuric nitrite.

The experiment was repeated with the exception that the rotor tube was kept moving for 5 hours just above the surface of the mercury.

Weight of silver found = 2.4 mgrs.

" mercury found = 115.9 "

" nitrous acid found = 58.3 "

" " in combination with Hg = 57.2 "

" " calculated to

$\text{Hg}(\text{NO}_2)_2 = 54.5 "$

It is evident that mercuric nitrite is present at the end, but there is the probability that the mercurous salt is also formed and decomposed in the dilute solution, giving mercury and the mercuric salt. The results show clearly the advantage of the rotation method in experiments of this kind.

Mercury and Nitrous Acid.—Two experiments were made with free nitrous acid, the first solution containing 101.8 mgrs. and the second 203.6 mgrs. of nitrous acid. The rotor was kept moving for 2 hours in each case, but no indications of the metal were found in the solutions and the nitrous acid had diminished to 41.7 and 74.1 mgrs. respectively. Evidently nitrous acid in the presence of small quantities of nitric acid attacks the metal very slowly, if at all.

Bismuth and Silver Nitrite.—The bismuth tube was rotated for 2 hours in 100 c.c. of solution containing 200 mgrs. of the nitrite. The solution became opalescent almost immediately, and this appearance deepened as the experiment proceeded. When the rotation was finished the solution was poured into excess of sodium hydroxide, and made up to 250 c.c. The nitrous acid was determined in the clear solution, and the bismuth in the precipitate.

Bismuth found = 42.1 mgrs.

Nitrous acid found = 29.2 "

Calculated to satisfy $\text{Bi}(\text{NO}_3)_3 = 28.6 "$

Bismuth and Nitrous Acid.—The tube was rotated for 3 hours in 50 c.c. of a solution containing 50.9 mgrs. of free nitrous acid. The solution was poured into excess of sodium hydroxide and made up to 250 c.c. There were no signs of a precipitate on standing for 12 hours and the clear solution was found to contain 16.7 mgrs. of nitrous acid, showing a loss of 34.2 mgrs. during rotation. Free nitrous acid in the presence of small quantities of nitric acid exerts no action upon bismuth, and the presence of potassium sulphate should have little or no effect.

Lead and Silver Nitrite.—The lead tube was rotated for 2 hours in a solution containing 100 mgrs. of the nitrite. The solution was filtered and titrated for nitrous acid. The lead was precipitated by the sulphuric acid used to liberate the nitrous acid in the hydroxide solution. The

whole of the solution was boiled down and allowed to stand for the lead sulphate to separate. The metal was then determined in the sulphate.

Lead found = 174.8 mgrs.

Nitrous acid found = 27.4 "

Calculated to satisfy $\text{PbNO}_3 = 27.1 "$

The formation of the lower nitrite as shown by this experiment is somewhat remarkable as the general tendency of lead is to form "ic" salts.

Lead and Nitrous Acid.—The experiment described above with bismuth was repeated with lead. The solution was found to contain 25.3 mgrs. of nitrous acid, thus showing a loss of 25.6 mgrs. After determining the nitrous acid the solution which contained sulphuric acid, was boiled down until the acid began to fume. It was then diluted and allowed to stand. No trace of lead precipitate could be detected. There is then practically no reaction between lead and free nitrous acid. But it must be borne in mind that the potassium sulphate might prevent the action taking place.

Iron and Silver Nitrite.—The iron tube was rotated for 5 hours in 100 c.c. of a solution containing 200 mgrs. of the nitrite. There was no sign of precipitation of silver on the bright surface of the tube. The solution was neutralised with excess of sodium hydroxide, the silver precipitate dissolved in nitric acid, and the metal separated as chloride. The solution was boiled down, ammonia added in excess and again boiled. A mere trace of iron showed on standing. The solution contained 59.5 mgrs. of nitrous as compared with 59.9 mgrs. in the original solution.

Iron and Nitrous Acid.—The tube was rotated for 2 hours in 100 c.c. of solution containing 200 mgrs. of the nitrite and 10.6 c.c. of the sulphuric acid solution containing 107.3 mgrs. of the acid. The solution turned red, which gave the impression that the iron was oxidising. The tube was washed, the contents of the beaker poured into excess of sodium hydroxide and made up to 250 c.c. The precipitate was dark green in colour, pointing to its formation from a ferrous salt. The precipitate was dissolved, and the iron determined by ammonia.

Iron found = 50.1 mgrs.

Nitrous acid found = 61.0 "

Calculated to satisfy $\text{Fe}(\text{NO}_3)_3 = 84.1 "$

The solution showed a loss of 40.8 mgrs. of nitrous acid which is equivalent to the formation of 18.2 mgrs. of nitric acid, and that may account for the excess of iron over nitrous acid in the solution. The alternative is that the ferrous nitrite is basic in composition.

Silver and Nitrous Acid.—A silver tube was rotated for 2 hours in a solution containing 500 mgrs. of the nitrite and 25 c.c. of the sulphuric acid solution. Only a trace of silver could be detected in the solution which contained 147.3 mgrs. of nitrous acid out of 254.5 mgrs. present at the commencement. This corresponds to the accumulation of 65.8 mgrs. of nitric acid in the solution. It is evident then that silver is not attacked by nitrous acid except in the presence of sufficient nitric acid.

It would appear from the results obtained that the reactions of the metals with silver nitrite enable the composition of their nitrites to be fixed with sufficient accuracy to determine whether the formation of the "ic" or the "ous" salt is the habit of the metal. The experiment with nitrous acid shows the attitude of the same metals towards the free acid, and may be of service in the consideration of the general reactions of nitric acid with the

metals. The methods should at least prove useful for further investigations.

The solution containing free nitrous acid, which is easily prepared as required from solutions of potassium nitrite and sulphuric acid of known strength, should be found useful as an etching agent for metallographic work. Thus, with alloys of copper and lead, the copper is attacked while the lead is left intact.

OILS, FATS AND MILK PRODUCTS.

By CECIL REVIS AND E. RICHARDS BOLTON.

PERHAPS nothing illustrates so well the profound effect that a comparatively simple invention may have on the commercial world, as the almost sudden introduction of hydrogenised oils into the fat and oil industry. We have referred to these products before, but the last six months has shown a development which is almost inconceivable in its extent. A paper read before the New York section of the Society of Chemical Industry by Ellis (*Journ. Soc. Chem. Ind.*, 1912, 31, 1155) gives a very complete view, both of the history and the expansion of these fats. While they are likely to be of untold value to the margarine and edible fat manufacturer, they have produced, at the same time, a most difficult and disconcerting problem for the chemist. The effect of the process is to practically destroy tests which the analyst has been accustomed to regard as the "sheet anchors" of his work. The bearing of this question has been investigated by Bömer (*Zeit. Unters. Nahr. Genussm.*, 1912, 24, 104); not only is the iodine value, as is to be expected, profoundly altered, but such tests as Halphen's, etc., are often rendered negative, and further, from the work of Stiepel (*Seifensieden Zeit.*, 1912, 39, 953, *abs. Chem. Zentralb.*, 1912, 2, 1751) it seems very probable that the "octobromide test" for marine animal oils, is likely to be rendered useless by hydrogenisation, in which case whale oil, which is being successfully treated, will be made difficult of recognition.

Special importance will now attach to the phytosteryl acetate test, as being probably the only reliable test for the detection of hardened vegetable fats. Bömer (*loc. cit.*) has also drawn attention to the very necessary examination for traces of the metallic catalyst used, as the physiological effect of these metals is probably deleterious.

From the analytical side a very useful modification of the Halphen test has been put forward by Gastaldi (*abs. Chem. Zentralb.*, 1912, 2, 758) in which pyridine is substituted for the usual amyl alcohol. It is contended by the author that impurities in the alcohol are the cause of the well-known reaction, and that by this change the test is rendered much more delicate. It should, therefore, be of value, as cotton seed oil varies much in its reactivity and quite slight colours are often obtained with certain pure specimens.

Evers (*Analyst*, 1912, 37, 487) has investigated Bellier's test, with regard to its use as a quantitative method. As originally given by Bellier, it was undoubtedly fallacious, but the modifications introduced by Evers seem to have rendered it reliable, though whether, as modified, it has any great superiority to Renard's method is a little doubtful. It is very worthy of note that Evers has drawn attention to the fact that arachidic and lignoceric acids are distinctly soluble in 70% alcohol, as usually the solubility has been regarded as negligible. In view of this a certain amount of

wonder is aroused at the remarkably accurate results which have been achieved by some users of Renard's test.

The Hübl method of determining iodine values dies hard, and an interesting paper by Auguet (*Ann. Falsif.*, 1912, 5, 459) accentuates the superiority of the Wijs method and at the same time clears up some of the causes of discrepancy in results obtained by the two methods, and, though pointing out ways in which these may be avoided, shows conclusively that, at least in point of time, the superiority lies with Wijs.

In connection with iodine values, a useful paper by Pongio and Gastaldi (*Garr. Chim. Ital.*, 1912, 42, 92) shows that a differential determination of this value will give evidence as to the position of the double bond in the acids of the series $C_n H_{2n-2} O_2$.

An investigation into the synthesis of triglycerides has been carried out by Belluci (*Garr. Chim. Ital.*, 1912, 42, 283) by heating palmitic, stearic and oleic acids under reduced pressure with glycerine at high temperatures. The synthesis is controlled by concurrent determinations of the acid and ester values, and seem to show that whereas a mixture of glycerides is at first produced, the final product is monoglyceride. These results, while in accord with those of enzyme action, seem a little opposed to the hydrolytic results obtained by others and to which we have referred in former articles. The results, however, seem to form a correct antithesis to the work of Fortini (*Chem. Zeit.*, 1912, 36, 111) on the saponification of triglycerides.

Smedley (*Biochem. Journal*, 1912, 6, 451) has re-investigated the fatty acids present in butter by the distillation process, and finds stearic acid present to the extent of 10%—15%. The result is extraordinary, in view of the usually accepted idea that this acid is practically absent in butter fat, and the result requires confirmation.

The past few months have seen the advent of two new milk products—"Synthetic milk" (*CHEMICAL WORLD*, Vol. II., p. 71) and "Jernut Cream." The former of these is well known now on account of the attention it has received in the daily press. The "milk" which is principally manufactured from soja beans, certainly has a similar analytical composition to that of ordinary milk, and a great future is supposed to lie before it. "Jernut Cream" appears on analysis to contain cocoanut oil and butter fat in the proportion of about 8:1, together with milk constituents and gelatine and possibly other substances, to keep the fats in an emulsified form. A certain amount of flavouring may be added and the result is not unlike the real article, though it does not pour like cream and has a somewhat thin taste.

While there is no objection to such products as the above, in themselves, it seems hardly right that such distinctive names as "milk" and "cream" should be allowed for them. If margarine may not be called "butterine," it is only just that products, which have no greater connection with the cow, should not be called by time-honoured names. There is, of course, no attempt at deception on the part of the manufacturers, but, as in the case of synthetic milk, the product has the support of well-known scientific men, the public are apt to believe that it is "just as good" as the real article. Now science has made great progress, and we can perhaps produce articles of an analytical composition identical with that of Nature's products, but it is well to remember that there is a very great gulf between the synthetic processes of Nature and those of the chemist, and until we know more about them care should be taken in the use of terms which may be misleading.

ABNORMAL FIXATION OF ATMOSPHERIC NITROGEN.

By C. T. GIMINGHAM, F.I.C.

As is well known, certain soil bacteria, by virtue of their special life processes, are able to make use of the nitrogen of the atmosphere and to bring it into combination. Some of these organisms are active only in association with higher plants, while others live separately in the soil; and of the latter group, by far the most important are the *Azotobacter* species, first described by Beyerinck. These bacteria have since been found to be widely distributed in soils from all parts of the world, the species most frequently noted being *Azotobacter chroococcum*, which produces a dark brown or black pigment under many conditions. The energy which is required for the fixation of nitrogen is obtained by the oxidation of carbohydrates or other carbon-containing compounds. In the soil, the decaying plant and animal remains are the source of the necessary carbon, and hence it is in virgin soils or land allowed to run wild (where every year most of the vegetation is returned to the soil), that any considerable fixation of nitrogen by these organisms takes place. Well-cultivated arable soils, on the other hand, fix little or no nitrogen. In this connection it may be mentioned that Hutchinson and Marr (7th Int. Cong. App. Chem., VII.) found that the addition of starch or sugar to an arable soil brought about an increased fixation of nitrogen by *Azotobacter* if the carbohydrates were applied in the autumn, directly after the removal of the crop and while the soil was still warm. The effect of such fixation was noted in the evident increase of crop in the following season.

In view of these and many other experiments tending to show the dependence of *Azotobacter* on a supply of carbohydrate for the manifestation of its activity, some work carried out by Headden on "The Fixation of Nitrogen in some Colorado soils" is very interesting and remarkable. In *Bulletin* 178 of the Colorado Agricultural Experiment station Headden describes the occurrence of certain soils, large areas of which have been rendered absolutely sterile by the accumulation of *nitrates* to an abnormal degree. The affected patches, which are characterised by their brown colour and the mealiness of the soil, often develop with great rapidity, and growing crops quickly succumb. In the majority of cases examined, the land was occupied by apple orchards, and the trees were being killed off, in bad cases, in from four days to two weeks, until, to quote from the author's summary, "very many square miles of otherwise good land have been rendered prejudicial or fatal to vegetation." The evidence is quite conclusive that the death of the trees was due to the excess of nitrates in the soil; indeed, the effects were exactly reproduced by the application of large amounts of sodium nitrate to the soil at the roots of healthy trees.

In the bulletin referred to, the author is at great pains to show, by giving details of upwards of twenty cases, that this abnormal accumulation of nitrates cannot be due to the evaporation of surface waters containing nitrates coming from a distance, since much of the affected land is at a high elevation, and both the natural water and the water used for irrigation contain only minute quantities of nitrates. Further, the trouble often occurs on thoroughly well-drained land, and the water level is always at a considerable distance below the surface. Headden is driven to the conclusion that the atmosphere is the source of the nitrogen and the action of *Azotobacter* the means by which

it is brought into combination. His experiments showed that with these soils "the rate of fixation of nitrogen is sufficient to account for the nitrates found in the soil provided that it is nitrified."

This conclusion was confirmed by Sackett (*Agric. Exp. Sta. Colorado, Bull.* 179), who studied the question purely from the bacteriological point of view. He found that the soils were especially rich in *Azotobacter*—the brown colour being due to the pigment produced by these organisms—and that nitrogen was fixed to a most unusual extent. In one case he obtained fixation at the rate of 10.5 mgms. nitrogen per 100 gms. soil in 27 days, and he calculates that this is equal to 2.85 tons of nitrogen per acre-foot of soil per year, easily enough to account for the nitrates found, if nitrification also takes place. Very large fixation was also shown to take place in culture solutions.

The presence of nitrate in the soil in limited amount did not apparently interfere with the growth of *Azotobacter*, but the excessive amounts finally formed caused nitrogen fixation to cease. It therefore appears that no further accumulation is taking place in the areas which have been rendered sterile, and though no case is recorded of the disappearance of a "nitre spot" once it is formed, yet there is some hope that the land may eventually again become fertile.

The conditions discussed in these two bulletins appear to be absolutely unique, and the detailed evidence supplied makes the remarkable conclusions arrived at seem inevitable. But how does the *Azotobacter*, in this case, obtain the energy necessary for such vigorous development and fixation of nitrogen? The soils concerned are of various types, but none possess an unusual amount of organic matter. The point is by no means clear. It is further, very difficult to understand such extremely rapid and abundant nitrification, and we must needs await further work before these aspects of the problem can be satisfactorily dealt with.

Technical Production of Ethane.—Colin Sprent recently described conditions before the Society of Chemical Industry where ethane was required on account of its low boiling point ($-93^{\circ}\text{C}.$) for use in a refrigerating machine, the capacity of which was about 600 kg.

After trying all other known methods, the author made use of Sabatier's method of "hydrogenation." Ethylene, in the presence of freshly reduced and finely divided nickel, can be made to combine with hydrogen, so that in the equilibrium



practically no remainder of either of the gases is left.

The chief difficulties encountered in the investigation to find the proper conditions for this action were, firstly, the production of pure ethylene, and, secondly, the quantitative saturation of this gas with hydrogen. Ethylene was prepared by the method of Maihle by passing alcohol vapour over alumina, and thereby resolving it into ethylene and water. The optimum temperature for this action appears to be $360^{\circ}\text{C}.$ Above this point, ethylene begins to decompose, and below it ether is likely to be formed in quantity. Ethylene so prepared needs some purification or it may impair the catalytic action of the nickel.

The purified ethylene and hydrogen were mixed in equal volumes by aid of the "Rotamesser," and then were passed into the oven containing the nickel.

SIR WILLIAM CROOKES, O.M., F.R.S.

By J. F. SPENCER, D.Sc., Ph.D.

RARELY, in these days, does one find a man who can be said to possess a specialist's knowledge of two such large branches of science as chemistry and physics. This distinction can, however, be claimed by Sir William Crookes, for physicists insist that he is one of their number, whilst chemists are equally confident that he is one of them.

Sir William Crookes was born in 1832 and entered the Royal College of Chemistry in 1848, where he studied chemistry under the guidance of Professor A. W. Hofmann. After two years he became assistant to Hofmann, and it was whilst employed in this capacity that he was introduced to the work which eventually led to his discovery of thallium. In 1854 Crookes was appointed to the post of Superintendent of the Meteorological Department of the Radcliffe Observatory, Oxford. Meteorology was, however, not his true vocation, and so he left this work after about a year and became Professor of Chemistry at the Training College, Chester. The call to original work was too strong to be resisted, and after about a year at Chester, Crookes resigned his position and set up a private laboratory in which, with the exception of his work on thallium, all his investigations have been carried out. The discovery of thallium by Crookes was due to that trait in his character which is continually leading him to examine the residue—that portion of a substance or quantity which most men ignore. Hofmann had given Crookes a quantity of "flue-dust" from which he was to extract the selenium; there was naturally a residue and this Crookes examined spectroscopically and found that the spectrum contained a bright green line which belonged to none of the then

known elements. Further work followed and resulted in the isolation of thallium. The complete investigation of the derivatives of thallium occupied about eleven years of Crookes's time. This work was not straightforward and smooth, for in the careful weighings, necessary for the determination

of the atomic weight, he was troubled by irregularities which were also present when the weighings were carried out *in vacuo*. The investigation into the cause of the irregularities led to a further discovery which he named "repulsion from radiation." Illustrative of this repulsion he invented the well-known radiometer. This work, as is well-known, led to the opening of a new chapter in the dynamical theory of gases. To a mind of the nature of Crookes's it was but a step to undertake the investigation of the electrical discharge in rarefied gases, from which he was led to the recognition of "radiant matter" which he regarded as a fourth state of matter. The beautiful apparatus which he invented for demonstrating the phenomena he had observed is now in everyday use in all physical



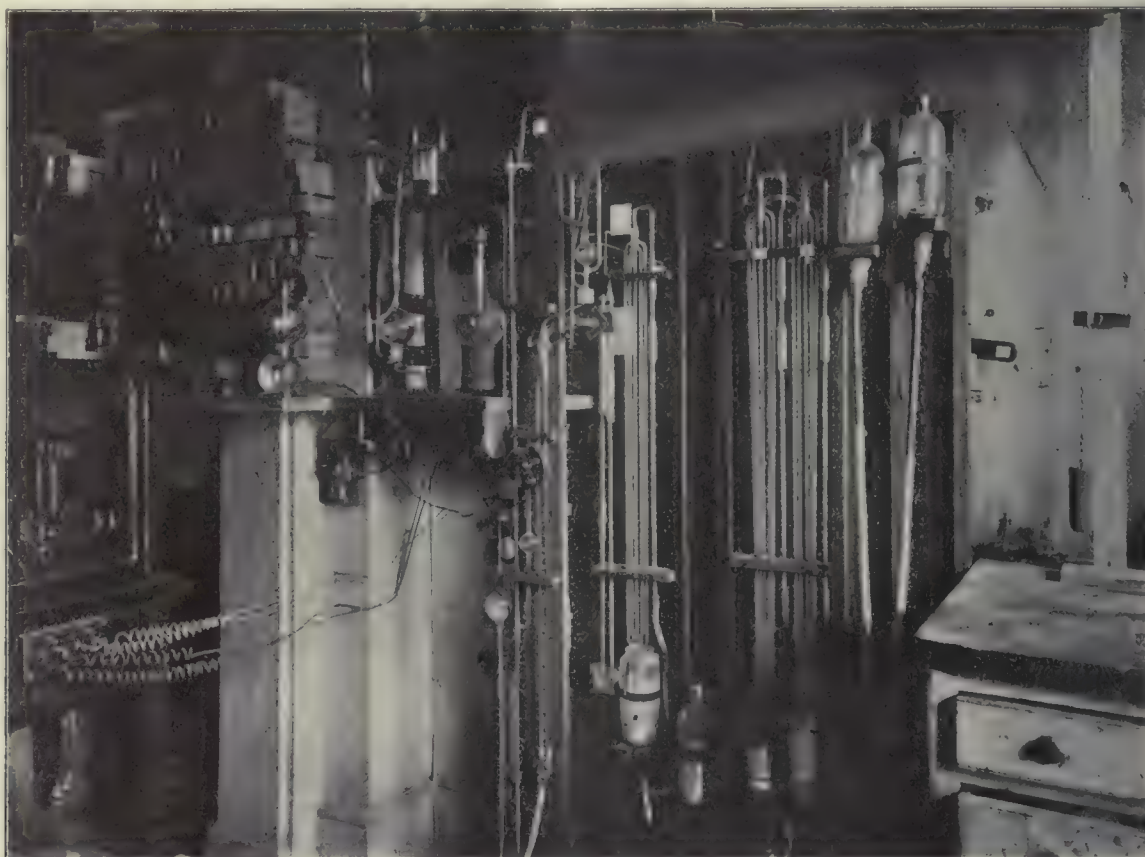
William Crookes.

laboratories. It was necessary to put forward hypotheses to explain the phenomena observed in the discharge through rarefied gases, and those put forward by Crookes are now generally accepted. It is not too much to say that Crookes's pioneer work in this field has done much to facilitate the work of recent years on this subject. Crookes's spectroscopic work is of tremendous importance; he has made many improvements in the construction of accurate spectrographs, among which may be mentioned his quartz slit with which he was able to work with a slit of 0.0001 inch. He introduced

the examination of phosphorescent spectra, *i.e.*, the spectra of the phosphorescent light emitted by substances when subjected to cathode rays. This type of spectrum analysis is extremely useful in work on the rare earths, as has been abundantly shown by Crookes and others. Sir William has always been specially attracted to spectrum analysis and is continually on the outlook for spectrum evidences which shall indicate the existence of hitherto unknown elements. This fact is well-known, and consequently he is constantly receiving sections of meteoric stones for examination. He has

telegraphy long before this branch of telegraphy became an accomplished fact, and since these are not generally known it may perhaps not be out of place to mention some of them here. In the *Fortnightly Review* of February, 1892, he writes:—

"Rays of light will not pierce a wall . . . but the electrical vibrations of a yard or more wave-length, of which I have spoken, will easily pierce such mediums. . . . Here, then, is revealed the bewildering possibility of telegraphy without wires, posts, cables or any of our present costly appliances. . . . At the present time experimentalists can



SPARK SPECTRUM APPARATUS.

examined hundreds of these, but up to the present he has not found anything which was not already known. Sir William's spectrum atlas is a work which is bound to fill anyone who has seen it with envy. It is contained in seven thick double folio volumes and contains photographs on a large scale of all the elements. The photographs have all been made by Crookes himself, and the larger part of the work has not been published in any form. Without doubt this work completely dwarfs all publications on the subject, and it is to be hoped that at no distant date Sir William may be prevailed upon to give the large amount of valuable and accurate work contained in this book to the scientific world by allowing it to be published *in extenso*. Having worked so much with electrical radiations it is not surprising to find that Crookes had ideas on wireless

generate electrical waves of any desired wave-length from a few feet upwards, and keep up a succession of such waves radiating into space. . . . Also, an experimentalist at a distance can receive some, if not all, of these rays on a properly constituted instrument and by concerted signals, messages in the Morse Code can thus pass from one operator to another. What, therefore, remains to be discovered is, firstly, simpler and more certain means of generating electrical rays of any desired wave length, from a few feet in length to those long waves whose lengths are measured by tens, hundreds and thousands of miles, secondly, more delicate receivers which will respond to wave-lengths between certain limits and be silent to others; thirdly, means of darting the sheaf of rays in any desired direction. . . . At first sight an objection to this plan

would be its want of secrecy. . . . This could be got over in two ways. . . . If the exact position of both sending and receiving instruments were accurately known, the rays could be concentrated on the receiver. If, however, this were impossible the correspondents could attune their instruments to a given wave-length. . . . All the requisites needed to bring this within the grasp of daily life are well within the possibilities of discovery and are so reasonable and so clearly in the path of researches which are now being actively prosecuted in every capital of Europe that we may any day expect to hear that they have emerged from the realms of

their bombardment on screens of zinc sulphide produced a brilliant phosphorescence. This latest and most wonderful of modern scientific discoveries, namely, the visual proof of the existence of atoms, he popularised by his invention of the "Spintharoscope." Naturally he determined the spectrum of radium, and in his atlas there is a complete spectrum of radium, which if it were to be remade to-day would involve the expenditure of over £1,000 for radium which would necessarily be dissipated in the process. Perhaps one of the most exciting and deeply significant problems attacked by Crookes is his study of the rare earths, and his views on the constitution



PHYSICAL LABORATORY.

speculation into those of sober fact. Even now, telegraphing without wires is possible within a restricted area of a few hundred yards."

Thus it will be seen that although Crookes nowhere receives any credit for the introduction of wireless telegraphy, yet his views on the subject were published before it was accomplished, and in the light of what has since transpired it will be obvious how extremely accurate they were. The great discovery of radioactivity could not possibly pass Crookes by; here we find that he has also played his part. In 1900 he separated uranium X from uranium by two distinct chemical methods and showed that uranium X loses its activity at the same rate as that at which uranium regains its lost activity. He also showed in 1903 that α -rays by

of matter which are the natural corollary of his experiments. There are many researches of Crookes on the rare earths which might be referred to, for his knowledge on this subject is second to none, and is mostly derived from his own work. The theoretical conclusions which he came to as a result of his fractionation of yttrium are at the moment of singular interest. They are of the nature of speculations on the origin of matter and are summed up in his presidential address to Section B of the British Association in 1886. In this address he draws a picture of the gradual formation of the chemical elements by the working of electricity, chemism and temperature on the formless mist "protyle," in which all matter was in a preatomic state—potential rather than actual. In this scheme

the chemical elements owe their stability to their being the outcome of a struggle for existence; the elements of lowest atomic weight were formed first, then those of intermediate weight, and finally those of highest atomic weight, thorium and uranium. In this paper he speaks of the dissociation point of the elements and asks what comes after uranium. He answers the question himself. The compounds will next be formed. To illustrate this evolution of the elements he designed a "figure of eight" periodic arrangement which has proved an excellent aid to lecturers dealing with the Periodic Classification. The foregoing were the views of Crookes a quarter of a century ago; when one considers the views prevailing to-day one must recognise in Sir William Crookes a veritable chemical prophet. Of the other researches of Crookes only one or two can be mentioned in passing, a mere recapitulation of their titles would fill all the space at the writer's disposal. Of his work on diamonds which involved two journeys to South Africa, his work on the viscosity of gases at high degrees of exhaustion, his work on the volatility of the platinum metals, and many others, one can say nothing here beyond expressing one's admiration of the daring which has allowed him to undertake such problems, and the consummate skill with which they have been pursued. Before leaving the strictly academic investigations of Crookes a faint estimate of their number if not of their importance may be conveyed by the statement that he has published eighteen papers in the *Transactions of the Royal Society*, and 250 in the *Proceedings of the Royal Society*, *Journal of the Chemical Society*, *Chemical News*, and other journals.

The research work of Sir William Crookes has not all been in the physical sciences; he has devoted much time and brought his highly-trained and acute intelligence on to problems which, as yet, are not generally admitted into the realm of scientific investigation, namely, psychical matters which he believes will eventually have to be placed alongside physical subjects as capable of exact investigation. The present writer does not claim in any way to be capable of judging these matters, but may perhaps be permitted to quote a few lines from Sir William Crookes's presidential address to the British Association, 1898, which show the attitude of mind in which this work has been taken up. He says:—"To stop short in any research that bids fair to widen the gates of knowledge, to recoil from fear of difficulty or adverse criticism is to bring reproach on science. There is nothing for the investigator to do but to 'explore up and down, inch by inch, with his reason the taper,' to follow the light wherever it may lead, even should it at times resemble a will o' the wisp. I adhere to my published statements, indeed, I might add much thereto. I regret only a certain crudity in those early expositions which, no doubt justly, militated against their acceptance by the scientific world."

Those are evidently the words of a courageous man confident himself of what he has said and failing only to make other people of the same opinion

as himself. It may be that time will show that once again Crookes is a true prophet even as he has already more than once been in matters not one jot less wonderful and apparently unlikely. It must not be supposed that in Sir William Crookes we have a visionary or even a dry as dust scientist, for he has been a man who, during the whole of his long life, has played his part as a citizen and has never failed to give of his best for the good of his fellow citizens.

In this connection one may point out the definite way he has spoken in his presidential address to the British Association in 1898 on the wheat problem, and of the resultant research on the fixation of nitrogen for the production of artificial manures which it occasioned. In 1907 he became consulting expert to the Ordnance Board. He indicated the best method for growing beet for sugar manufacture. He lent his great intellect to the subject of the cattle plague. Of his work on the disposal of sewage and the maintenance of a pure water supply nothing need be said here. Sir William has written many books, among which we may mention: "Application of Disinfectants in arresting the Spread of the Cattle Plague" (Blue Book), 1886; "Manufacture of Beetroot Sugar in England," 1870; "Handbook of Dyeing and Calico Printing," 1874; "Manual of Practical Assaying," 1873 and 1881; "Dyeing and Tissue Printing," 1882; "Select Methods of Chemical Analysis," 1871, 1886, 1894 and 1905; "Reports on the Constitution and Quality of Daily Samples of the Water supplied to London" (with collaborators), 1880-1906; "The Wheat Problem," 1889 and 1905; "Diamonds," 1905.

He has, at various times, acted as editor of many scientific journals, among which is his own paper *The Chemical News* which he founded in 1859 and has edited ever since.

Honours have been richly and not undeservedly bestowed upon Sir William by his Sovereign, by his fellow chemists and physicists, and by the general public.

In 1862 he received a medal at the International Exhibition for the discovery of a new element, and at various times he has been the recipient of over thirty other medals including the Royal Medal, Davy Medal and Copley Medal of the Royal Society; The Gold Medal of the French Academy and the Medal of the Society of Chemical Industry.

Universities have deemed it an honour when he has accepted their degrees. The following honorary degrees are among the many which have been awarded him, LL.D. of Birmingham; Sc.D. of Cambridge and Dublin; D.Sc. of Oxford, Sheffield and Cape of Good Hope.

He has been President of the Chemical Society, British Association, Institute of Electrical Engineers, and Society of Psychical Research. He is an honorary member of some twenty scientific societies in all parts of the world.

In 1911 his portrait in oils was subscribed for by his admirers and presented to the Royal Society in whose rooms it now hangs.

The crowning honours were conferred upon him, when, in 1897 he was knighted by Queen Victoria

and when, in 1910, the "Order of Merit" was conferred upon him.

Truly a remarkable record is his, one of which he, and we as Englishmen, have every reason to be proud. And the record is not yet full, for he is still daily active in his laboratory, and it is the hope of all his well-wishers that he may for long be able to

elucidate the fascinating problems with which he is engaged. He himself feels confident of this, for in a speech delivered last year he made the following statement:—"I hope and believe I shall still be able to do good work in my research laboratory, and this, notwithstanding the ominous assurances of my friends, that I grow younger every year."

COLLOIDAL CHEMISTRY IN 1912.

By EMIL HATSCHEK.

WHILE there is no discovery of outstanding importance to be chronicled, activity in the field of colloidal chemistry and physics has been considerable during the past year and a large body of research on both theoretical and practical problems deserves reference.

Among papers dealing with fundamental questions of classification is one by Wolfgang Ostwald¹ on the emulsoid state, in which the author deals with various objections against his division of colloids by emphasising that the term "emulsoid" postulates something more than merely a fluid disperse phase. A ready exchange of solvent between the two phases under the influence of temperature or dissolved substances, and the possibility of separating the sol into two liquid phases are equally characteristic of these systems. Points of considerable importance for the theory of suspensoids are brought out in two papers by Sven Oden,² who investigates sulphur sols, fractionated by Th. Svedberg's method into portions containing particles of uniform size. In the first paper he shows that the stability of these sols increases, *i.e.*, the amount of electrolyte required to coagulate them becomes larger, as the particles become smaller. In the second he determines various physical constants of these sols and finds them in the main simply additive, with the exception of the viscosity, which deviates considerably and, for the same weight of disperse phase, is greater for small than for large particles. E. Hatschek³ deals with this anomaly and explains it by the adsorption layer generally supposed to surround the particles, the total volume of which is proportional to the surface and therefore—supposing equal weights—greater with small than with large particles.

The formation of suspensoid sols, especially of metals, receives attention from a number of observers. Mme. Traube-Mengarini and A. Scala⁴ continue their very important investigation on the spontaneous dispersion of solid metals in water, and find that sols of iron, zinc, copper, nickel, tin and lead may be obtained by contact at ordinary temperature—in *vacuo* where the metal is readily oxidised. An interesting class of organosols of metals is described by Amberger,⁵ wool-fat being

used as protective colloid. A concentrated aqueous solution of a metallic salt is incorporated with the wool-fat, decomposed by alkali, and the metal reduced by a suitable reducing agent. It then forms sols readily with any of the solvents for wool-fat. The formation of sols by the disruption of metals in the electric arc and the oscillating discharge is discussed by Kutscherow⁶ and by Benedicks.⁷ The former comes to the conclusion that "the quantities of different metals disintegrated are, *caeteris paribus*, proportional to their equivalent weights" and that the whole process is accordingly largely an electrochemical one. Benedicks criticises this result and adopts the view of other investigators that the phenomenon is largely due to fusion and in extreme cases vaporisation of the electrodes, supporting this explanation by what appears conclusive evidence.

As regards the optical properties of colloidal solutions, investigation confines itself practically to the connexion between colour, *i.e.*, absorption and the degree of dispersity. Wolfgang Ostwald⁸ describes the results of an ultra-microscopic investigation of fifty dye-stuffs of the indicator class. He finds that in neutral solution twenty-eight of these show particles, thirteen are highly disperse and only eleven optically empty. In most—forty-two out of fifty—cases the systems, whether originally suspensoid, emulsoid, or even empty, become coarser both with acid and with alkali. The change in colour is thus generally accompanied by an alteration in the degree of dispersity, which in the majority of instances agrees with Wolfgang Ostwald's rule, *viz.*, with increasing dispersity the maximum of absorption is shifted towards the shorter wave-lengths. Various apparent exceptions to this rule, adduced by Harrison,⁹ are also dealt with by Ostwald. Nils Pihlblad¹⁰ continues an investigation begun with Svedberg, the results of which tend to show that with increasing dispersity the colour absorption approaches more and more to that shown by the substance when in molecular or ionic dispersion, *i.e.*, in true solution. In the present case this is shown to hold good for a number of dyestuffs which

¹ Koll.-Zeitschr., 11, 230.

² Zeitschr. Phys. Chem., 80, 709.

³ Koll.-Zeitschr., 11, 280.

⁴ Koll.-Zeitschr., 10, 113.

⁵ Koll.-Zeitschr., 11, 97.

⁶ Koll.-Zeitschr., 11, 165.

⁷ Koll.-Zeitschr., 11, 263.

⁸ Koll.-Zeitschr., 10, 97, 132.

⁹ Koll.-Zeitschr., 10, 45.

¹⁰ Zeitschr. Phys. Chem., 81, 417.

form both true and colloidal solutions in various organic solvents.

Adsorption phenomena receive the usual large amount of attention. Rakowski¹¹ investigates the adsorption of water by starch, and finds that the function connecting the adsorbed amount and the vapour tension is a harmonic function. In the case of silicic acid gels, as studied by van Bemmelen, the conditions are very much more complicated. The time function of the same adsorption is treated by R. in a further paper. Aberson¹² examines adsorption by soils, and finds it to conform generally to the laws established for other adsorbents, such as charcoal. Estrup and Andersen¹³ investigate the adsorption of permanganate and some other salts by barium sulphate of different degrees of dispersity, and obtained well-marked maxima and minima of adsorption. A further paper by Estrup¹⁴ describes the adsorption of ammonium iodate, chromate and bichromate in acid and alkaline solutions; negative adsorption of the anion occurs in a number of cases, but the author does not enter into the theory of the phenomenon. Gurwitsch¹⁵ finds strong evidence of adsorption being accompanied by polymerisation (amylene to diamylene). Dreaper and Davis¹⁶ deal with the relative adsorption of night blue by sand and by fibres, and find that the same concentration of alcohol in all three cases stops adsorption, or redissolves the adsorbed dye.

Gels and various phenomena in gels are the subject of several papers of importance. Zsigmondy and Bachmann¹⁷ give a large number of magnificent ultra-micrographs of soap jellies, on which they base a discussion of the theories of gel structure. The soap jellies show a fairly coarse crystalline structure, and the authors reject the "honeycomb" theory, or at least its general applicability. V. Weimarn,¹⁸ however, doubts whether these soap jellies, which are opaque, can be considered as typical gels at all. The question of gel structure is also raised in an investigation by F. Hatschek¹⁹ on the gel-forming properties of a crystalline organic compound, a camphoryl derivative synthesised by M. O. Forster. This substance forms perfectly clear unstable gels in various solvents at very low concentrations, in petroleum, *e.g.*, at 0.25%. W. Doehle²⁰ also describes an organic compound—the mercury salt of a sulphoacid—which shows this property of transient gel formation in small concentrations. As regards reactions in gels, E. Hatschek²¹ gives the results of experiments in silicic acid gels, which have not previously been used for this purpose. The formation of large spherical and spherulitic aggregates of the reaction products is even more marked than in organic jellies. The reduction of gold in silicic acid

gels by various agents—including gases—is described by the same author and A. L. Simon,²² and the results are made the basis of a theory of the formation of gold-bearing quartzes. An interesting practical application is made by E. Marriage,²³ who studies the formation of lead iodide in fruit jellies, and finds that it is possible to differentiate them and to detect admixtures, like agar, by the microscopic appearance of the precipitate. The same reaction is employed by E. Hatschek²⁴ to disprove Wilhelm Ostwald's explanation of Liesegang's stratifications, which assumes that the product of the reaction first appears in metastable supersaturated solution. If, however, the lead iodide reaction is produced in a gel already containing crystalline lead iodide, stratifications are still formed, although supersaturation is obviously impossible.

Freundlich and Seal²⁵ devote a paper of great theoretical importance to the properties of the thiocyanate ion, which the former calls "lyotropic," viz., the effect of salts containing this anion on compressibility, surface tension, solubility of other substances, etc. The peculiar effect of this ion on several colloidal processes has long been known, such as the depression of the setting temperatures of gels, the prevention of the heat coagulation of albumin, etc., and the co-ordination of such effects with the others, enumerated above, may be expected to throw considerable light on the mechanism of these still obscure phenomena.

Among works dealing with particular colloids may be mentioned two further papers by Chick and Martin,²⁶ in which the authors continue their investigations on the heat coagulation of proteins. The first is largely devoted to the effect of hydroxyl ions on the denaturation, *i.e.*, "the first process in the precipitation of proteins by hot water," while the second deals chiefly with the electrical conditions of the coagulated protein. The same authors study the concentration and the temperature function of the viscosity of casein sols, which permit measurements over a larger range of temperature than the other proteins hitherto investigated in this direction.

Rubber, and more particularly the theory of vulcanisation, receives a fair amount of attention. The latter problem is the subject of an animated controversy between Spence and Young,²⁷ Ostwald,²⁸ and Hinrichsen and Kindscher,²⁹ which leaves the outsider with the impression that the question of adsorption *versus* chemical combination still awaits settlement. Beadle and Stevens³⁰ deal with the "insoluble" nitrogenous constituent of natural rubber, and suggest that it acts both as a sulphur carrier and as a structural element. Lewis and Waumsley³¹ describe the formation of colloidal

¹¹ *Koll.-Zeitschr.*, 10, 22, 11, 19.

¹² *Koll.-Zeitschr.*, 10, 13.

¹³ *Koll.-Zeitschr.*, 10, 161.

¹⁴ *Koll.-Zeitschr.*, 11, 8.

¹⁵ *Koll.-Zeitschr.*, 11, 17.

¹⁶ *Jnal. Soc. Chem. Ind.*, 31, No. 3.

¹⁷ *Koll.-Zeitschr.*, 11, 145.

¹⁸ *Koll.-Zeitschr.*, 11, 239.

¹⁹ *Koll.-Zeitschr.*, 11, 158.

²⁰ W. Doehle, *Dissertation*, Leipzig, 1912, 14, 61.

²¹ *Koll.-Zeitschr.*, 10, 77.

²² *Trans. Inst. Min. and Met.*, 21, 457; also *CHEMICAL WORLD*, June, 1912.

²³ *Koll.-Zeitschr.*, 11, 1.

²⁴ *Koll.-Zeitschr.*, 10, 124.

²⁵ *Koll.-Zeitschr.*, 11, 257.

²⁶ *Jnal. of Physiol.*, 45, 61, 261.

²⁷ *Koll.-Zeitschr.*, 11, 28.

²⁸ *Koll.-Zeitschr.*, 11, 34.

²⁹ *Koll.-Zeitschr.*, 11, 191.

³⁰ *Koll.-Zeitschr.*, 11, 61.

³¹ *Jnal. Soc. Chem. Ind.*, 31, No. 11.

metallic sulphides in rubber solutions containing carbon bisulphide, in which the rubber presumably acts as protective colloid.

Cellulose and allied carbohydrates are treated in two lectures delivered before the Institute of Chemistry by C. F. Cross,⁸² in which the necessity of investigating these bodies as typical colloids is insisted upon with considerable emphasis. In a short but important paper v. Weimarn⁸³ applies his well-known views on the general possibility of obtaining sols of any substance by suitable peptisation methods to cellulose. He finds that celluloses of various origin can be dispersed in solutions of a large number of salts, those which are particularly

⁸² Lectures on Cellulose, Inst. Chem., 1912.

⁸³ Koll.-Zeitschr., 11, 41.

effective being characterised by very great solubility and a high degree of hydration. In some cases, as with the iodides and thiocyanates of calcium, barium and strontium, boiling at atmospheric pressure is sufficient to effect peptisation of cellulose, while in others the temperature and the solubility have to be raised by the use of pressure.

The following text-books published during the past year must be mentioned: "Kolloidchemie," by R. Zsigmondy (Leipzig, Otto Spamer); "Die Kolloide in Biologie und Medizin," by H. Bechhold (Dresden, Theodor Steinkopff); Leonardo Cassuto "Lo stato colloidale della materia" (Pisa), and the third (unchanged) edition of Wolfgang Ostwald's "Grundriss der Kolloidchemie," Part I. (Dresden, Theodor Steinkopff).

MOLECULAR PHYSICS.

By J. A. CROWTHER, M.A. (Fellow of St. John's College, and Demonstrator in Physics in the Cavendish Laboratory, Cambridge.)

CHAPTER II.—Continued.

THE PHYSICS OF THE ELECTRON.

THE mechanism of ionisation by the electrons emitted by a metal plate under the action of ultra-violet light is somewhat different. Here the electrons have not sufficient energy to expel an electron from the atom and thus no positive ions are produced in the gas. The negative electrons, however, attract to themselves neutral molecules to form negative ions. It will be evident from the mode of formation that these ions bear the same charge as the electron which gave rise to them, that is to say, their ionic charge is the same as the electronic charge e . It may be pointed out in passing that since the ions are all of the same sign and produced at the same place, namely, the surface of the metal plate, a current can only be sent through the gas in one direction. If the metal plate is negative the ions will be repelled and thus carry a negative current from it to the positive electrode. If, however, the plate is positively charged the ions will be attracted back to it by the field and the gas will remain an insulator.

It occurred to C. T. R. Wilson that these ions might possibly serve as nuclei for the production of a fog or cloud in supersaturated air, and this was found on experiment to be the case. He was able to show that drops of water would condense on these negative ions when the supersaturation was only fourfold, while condensation occurred on the positive ions also when the supersaturation was sixfold. It was found that when the supersaturation was increased to the proper extent each negative ion became the centre of a single drop of water, and if the conditions were fairly uniform these drops were all of the same size. It will be remembered that in the case of the ions formed by ultra-violet light each of these drops will carry with it the electronic charge e , the magnitude of which we wish to determine.

Every drop in a cloud is falling through the air under the action of gravity with a definite velocity. Clouds do not float in the air, though, if the drops are sufficiently small they fall very slowly, owing to the great surface they present in comparison with

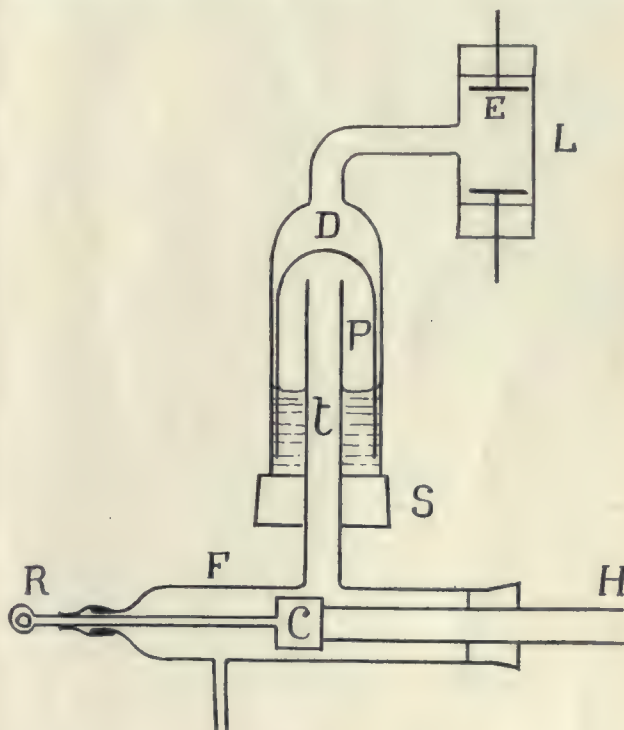


FIG. 4.

their mass to the viscous drag of the air. Sir G. G. Stokes has shown that if r is the radius of a small drop of water and η the viscosity of the air, the velocity with which the drop will fall relative to the air is $\frac{2gr^2}{9\eta}$, where g is, as usual, the acceleration

due to gravity. The drops formed round the ions are all of the same size and fall at the same rate. We can thus measure the velocity v of their fall by watching the rate at which the surface of the cloud settles. This will enable us to calculate the radius r of the drop, and hence its mass M .

So far the cloud has been falling freely under the action of gravity. Let us apply a field of strength X in such a direction as to oppose the action of gravity, that is to say, with the positive plate above the cloud. The force on each drop due to the electric field is then $X \cdot e$, while that due to gravity is $M \cdot g$. We can adjust the field X until these two forces exactly balance each other, and the drop remains suspended in air like Mahomet's coffin. When this stage is reached we have

$$X \cdot e = M \cdot g$$

$$\text{or} \quad e = M \cdot g/X.$$

But all these quantities are known, and thus the charge on the drop of water, which we have shown to be the same as that on the original electron, can be determined.

It remains to describe the apparatus devised for the experiment. It is shown in Fig. 4. It is well known that if a mass of gas is expanded in such a way that no heat is allowed to enter or leave it, the temperature will fall. The lowest temperature reached in any given expansion can be calculated from the gas laws if the ratio of the specific heats of the gas is known. As gases are bad conductors of heat we can satisfy the conditions of the experiment by making the expansion sufficiently rapid. The mass of the gas is then cooled down to the calculated temperature before any appreciable amount of heat has had time to enter the system.

The method of making the expansion will be clear from the diagram. The tube H connects with a large bulb of some litres capacity kept exhausted by means of a water pump. It is closed by a rubber stopper C which can be suddenly withdrawn by means of the rod R, thus creating practically instantaneously a partial vacuum in this part of the apparatus. The air being thus suddenly withdrawn from beneath it, the light glass plunger P which had been adjusted to a suitable height in the cylinder D is forced down with great rapidity, thus producing within the experimental chamber L a very rapid expansion of an amount which depends only upon the initial position of the plunger P. The temperature in L is therefore suddenly lowered to a degree which can be calculated, and if the air in L was previously saturated it will now be super-saturated to an extent which is measured by P/p where P and p are the vapour pressures of water at the initial and final temperatures.

In making an experiment the air in L is freed from all material nuclei by repeated expansions; the plunger is adjusted so as to make the super-saturation after expansion rather more than fourfold, the upper plate E, which is usually of zinc, is illuminated with ultra-violet light for a moment in order to produce a suitable supply of negative ions in the gas and the expansion is made. A cloud is formed on the negative ions and the rate at which

the surface of it settles is taken. After it has fallen some little distance the upper plate E, which had been previously uncharged, is raised to a positive potential, and its potential adjusted until the surface of the cloud is seen to remain stationary. If P is this potential and the lower plate at a distance d from the upper one is earthed, the strength of the electric field is P/d and the electronic charge e is equal to Mgd/P , where M has been calculated by Stokes' law from the rate of fall of the cloud.

The method was first applied in a rather different form by Professor Sir J. J. Thomson. In the form described, which is the one which has been used with the greatest success, it was performed by H. A. Wilson. We have, for the sake of making our argument logically complete, considered the case of the electrons produced by ultra-violet light, for in this case we have evidence that the charge we are measuring is really that carried by an electron. It has been shown, however, experimentally, that the value of the charge e is the same no matter how the ions are produced. Experiments carried out with ions produced by Rontgen rays or the various rays from radio-active materials gave exactly the same values for the charge e . Like the ratio m/e , the charge e is a universal constant. Some recent determinations of it are given in the following table.

TABLE II.

Observer.	Carrier.	e (electrostatic units).
Begeman	Water drops (original method)	4.67×10^{-10}
Roux	Sulphur drops	4.17×10^{-10}
Ehrenhaft	Metallic dust	4.65×10^{-10}
Millikan	Oil or mercury spray	4.89×10^{-10}
Rutherford	[Counting the α -rays]	4.65×10^{-10}
Planck	Theory of radiation	4.69×10^{-10}

It will be seen from Table II. that the values obtained for the electron charge e by different observers working in different ways, though not so consistent as those obtained for the ratio e/m , yet do not differ much from a mean value of about 4.7×10^{-10} electrostatic units, or 1.57×10^{-20} in the absolute electromagnetic unit of charge which is equal to 10 coulombs.

The most extensive survey of the subject has been made by Millikan (see *Physical Review*, 1911). Instead of water drops he used very fine globules of oil or sometimes mercury produced by an atomiser or fine spray. These drops could be passed as required into his apparatus, which very much resembled the chamber L in Fig. 4, through a small hole made in the top plate. These globules did not evaporate appreciably, so that an individual drop could be isolated and kept under observation through a microscope for several hours consecutively. The microscope was fitted with an engraved glass scale in the eyepiece, on which the whole of the measurements on the motion of the drop could be made very accurately and conveniently.

By properly adjusting the difference of potential between the upper and lower plates the drop could be kept in the field of view during the whole of the experiment. The measurements made and the calculation of the charge are precisely the same for the oil globule as for the water drop.

These drops were not originally charged, but picked up their charges from the surrounding air, which was ionised either by Rontgen rays or by radium. These comparatively large globules could collect and carry more than one electronic charge, seven or eight being a very usual number, though some drops had many more than this. The interchange of charges between the globule and the air could be easily observed with the microscope. The drop which had been poised almost motionless in the



F.G. 5.

air for some time by the balanced action of gravity and the electric field would be seen to dart suddenly upwards, showing that the drop had captured another charge and thus caused the electric force to increase, or perhaps on the other hand the drop would be seen to fall, having parted with one of its charges to some colliding molecule.

The important point brought out by the experiment is that in every case it was found that the magnitude of the charge thus exchanged, which could be calculated by a simple application of the principles already explained, was exactly the electronic charge e , and the total charge on the globule at any time was always very exactly some integral multiple of this charge. An examination of the mass of figures collected by Professor Millikan leave no room for doubting that the charge which we have denoted by e is a universal constant, and that every electrical charge is made up of an integral

number of electrons, just as every fragment of an element is made up of a whole number of atoms.

From Table I. we have the ratio e/m , equal to 1.77×10^7 , for all electrons. Combining this result with the value just obtained for e we are driven to the conclusion that whatever the source from which they come all electrons have identically the same mass and charge, the former being 8.8×10^{-28} gms., the latter 1.57×10^{-20} coulombs. Such particles must form a constituent part of all matter.

The value of e ascribed to Professor Rutherford and also included in Table II. was obtained from experiments of an entirely different nature made on the α -particles. Before passing to these we must refer very briefly to an exceedingly beautiful extension of the method of drops which has recently been brought to perfection by the originator of the method.

In the experiments already described, the clouds obtained were fairly uniform, as the ionisation was intense and time was given for the ions formed to diffuse through the body of the gas. Suppose, however, that we allow, say, a single α -particle to cross our expansion chamber and at the same time make an expansion of the air in the chamber by the method already described. The particle passes through the air, ionising it as it passes, and thus leaving behind it a trail of charged ions. Water drops at once form upon these from the now supersaturated air before they have had time either to diffuse into the rest of the gas or to recombine.

If the expansion chamber is suitably illuminated these drops appear as brilliant points of light all along the path traversed by the particle. In the case of the α -particle the ions are so numerous that the track of the particle becomes visible as a continuous shining streak of light. In the case of an electron where the ionisation is less intense the appearance presented is that of a string of bright beads. We are thus able not merely to detect, but even to follow the path of a single particle of any kind providing it produces ionisation in a gas.

By the kindness of Mr. C. T. R. Wilson, I am able to reproduce two of the photographs taken by him in this way. In Fig. 5 are shown the paths of a number of α -particles. These have their origin in a small sample of radium placed just outside the chamber and shoot across the chamber



FIG. 6.

as shown in the photograph until finally their energy, which is being spent in the work of separating the ionic charges along the whole of the path, finally becomes too small to produce ionisation, and the particles disappear from human ken.

Fig. 6 is a photograph of the passage of a narrow beam of Rontgen rays through the expansion chamber, from A. to A.' We have mentioned before that the Rontgen rays produce rapidly-moving cathode rays when they fall upon matter; in this remarkable photograph these cathode rays are made visible to us by the ions they produce. Here upon the dark background their tracks may be seen as a tangled skein of bright threads radiating out from the invisible track of the Rontgen rays. Each single thread represents the whole path of a single electron from its expulsion from the parent molecule under the action of the Rontgen rays, to the place where it finally becomes too weak to ionise. In some of the brighter threads the individual drops are clearly to be seen. The twists and turns in each little path are due to collisions between the cathode particle and the molecules of the surrounding air, or, rather, perhaps, with the individual electrons contained in these molecules.

These photographs will perhaps do more than

any argument, however cogent, to remove any doubt which may still be felt as to the objective reality of the electrons and other particles with which we have been dealing. Nothing but an actual particle could leave behind it such tracks as those shown in the photographs we have reproduced.

We have not space to deal with the many difficulties of the experiment or with the skill and ingenuity with which they have been overcome. Those interested may be referred to the original paper in the *Proceedings of the Royal Society* for 1912.

The method is still in its infancy, and the photographs so far obtained are hardly more than trial exposures. Already, however, several heated controversies have been settled, and many cherished hypotheses dethroned, as the result of the photographs obtained. To those of us who have been working by indirect methods on some of the more obscure problems still left to us for solution, the method has come as a veritable giving of sight to the blind, and now that Mr. C. T. R. Wilson has perfected his apparatus and can turn his attention to using it as an instrument of research we may hope for many interesting and important results in the near future.

(To be continued.)

CHEMICAL ENGINEERING.

ELECTRIC FURNACE METHODS OF IRON AND STEEL PRODUCTION.

By JOHN B. C. KERSHAW, F.I.C.

(Continued from Vol. II., page 64.)

THE electric furnaces used for iron and steel production, may be divided into three classes:— (1) Arc furnaces; (2) resistance furnaces and (3) induction furnaces; according to the different methods of applying the principles of electric heating.

In Class I., *Arc Furnaces*, the heat effect is produced by radiation or conduction from an electric arc. This arc is formed by the passage of an electric current at from 90 to 120 volts pressure, across an air-gap, between two carbon electrodes placed at an angle of 30 degrees, with their points just above the surface of the metal to be heated; or between one or more vertical carbon electrodes and the surface of the metal itself, which then acts as the second electrode.

Henri Moissan was the first chemist to apply with success, electric arc methods of heating in the laboratory, and the remarkable series of researches carried out and of discoveries made by this famous French chemist in the years 1890—1895, have found a fitting record in his classical work "*La Four Electrique*," published in 1896.

The furnace used by Moissan in these researches and discoveries was formed of two solid blocks of lime, fitting closely the one over the other, but hollowed out at the centre to form a small cavity, in which the arc was formed and in which his high temperature effects were obtained.

The electric arc furnaces used for steel refining, are similar in principle, but are constructed on a much larger scale. The Stassano type of furnace most closely resembles that of Moissan, for it has the electrodes arranged at an angle of 30 degrees, and the heating effect is obtained by radiation from the arc formed above the surface of the metal. The Girod and Heroult furnaces are designed with vertical electrodes, and the molten metal itself acts as one pole, from which the arc springs. In these cases, therefore, there is actual contact between the metal or slag and the electric arc, and the heat transfer is partly by radiation and partly by conduction.

In Class II., *Resistance furnaces*, the heat effect is produced within the metal itself (according to Joule's law) by the resistance offered to the passage of the

current through it. Since the temperature attained by this method of heating cannot equal that attained in arc heating, the radiation and conduction losses are lower, and the thermal efficiency of the furnace is higher. On the other hand, certain refining operations that can be carried out with ease in the arc furnaces, cannot be successfully performed in resistance furnaces. The Röchling-Rodenhauser or combination furnace, is the best-known type of resistance furnace.

The *Induction furnaces* (Class III.), form only a sub-division of the resistance type of furnace, since the thermal effect is again due to the resistance of the metal to the flow of the current through it. In this case, however, "induced" currents of electricity are used, in place of direct currents. An "induced" electric current, is one that is created in any closed conducting circuit, when an alternating current is allowed to pass through a neighbouring (or parallel) circuit. The Induction furnace is, in fact, nothing but a huge transformer, in which a ring of molten

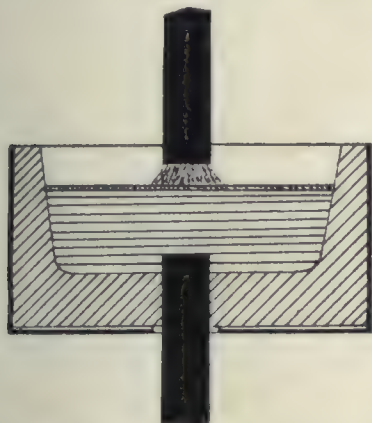


FIG. 1.—DIAGRAMMATIC SECTION OF A FORM OF ARC-FURNACE.

metal forms the secondary circuit, and becomes the focus of currents of large intensity but low E.M.F.

The disadvantages of this type of furnace are: its comparatively low temperature, and the necessity for retaining a certain proportion of every melt in the annular ring, in order to carry the current for melting the next charge. The great advantage is, that electrodes are dispensed with, and that this costly item of the running charges is wiped out. A secondary advantage is that the capital expenditure upon cables and conductors is greatly reduced.

The Kjellin and Frick furnaces are the best known examples of the induction type of furnace.

Figs. 1 and 2 are diagrammatic sections of the two forms of arc-furnace; Fig. 3 is a similar section of a simple resistance furnace; and Fig. 4 is a diagrammatic section of a simple induction furnace. The core and primary circuit in Fig. 4 are shown in the centre; the sections of the annular trough on each side contain the molten metal.

The distinguishing feature of arc heating is, that a very high temperature effect is concentrated chiefly on the surface of the metal, or of the slag covering it; whereas in resistance heating (whether

by direct or induced currents) a more moderate and uniform heat effect is produced within the body of metal contained within the furnace. The different types of furnace are tending, however, to approach one another in design; for it has been found that the washing-out processes by which the impurities, phosphorus and sulphur, are removed from the molten metal by means of suitable slags, can only be

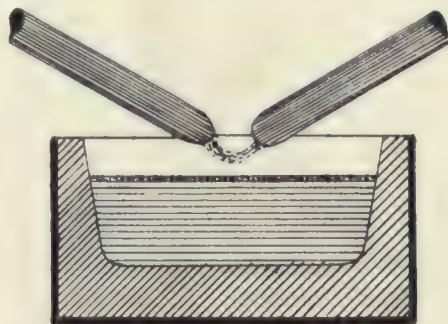


FIG. 2.—DIAGRAMMATIC SECTION OF A FORM OF ARC-FURNACE.

effectively and rapidly carried out with the aid of high temperatures.

Turning now from the consideration of the general principles and general features of design of electric furnaces for iron and steel production to a study of particular furnaces, we find that the first electric furnace for steel melting was patented by Charles William Siemens, of London, in the year 1879 (see British Patents No. 2110 of 1879).

Figs. 5 and 6 give a diagrammatic representation of the two forms of crucible furnace designed by Siemens, who also demonstrated that with this type of furnace he could melt 10 kgs. of iron or steel with comparative ease in one hour.

Though no industrial application of Siemens' furnace was made for the simple reason that electricity was at the time much too expensive a form of energy to be used for heating purposes outside the chemist's or physicist's laboratory, yet Siemens' invention was the prototype of the successful

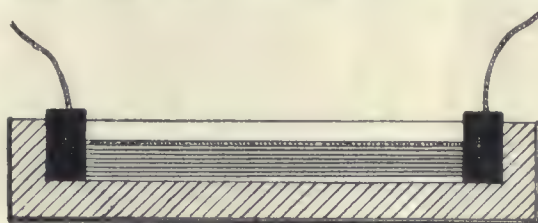


FIG. 3.—DIAGRAMMATIC SECTION OF SIMPLE RESISTANCE FURNACE.

Heroult and Stassano furnaces, which are now so widely employed in the steel refining industry.

As Charles William Siemens may be regarded as the originator of the arc-type of steel-melting and refining furnace, so may S. Z. de Ferranti claim to be the inventor of the induction type of furnace, though here again many years elapsed before any practical developments occurred.

Ferranti's first patent for the induction form of

furnace construction was taken out in 1887 (Patent No. 700), or thirteen years in advance of the first British patent granted to the Swedish engineer, Benedicks, for a similar type of furnace. The successful furnaces of Kjellin, Frick, Hiorth and Röchling-Rodenhauser, are all developments or modifications of Ferranti's original design.

The first successful industrial application of electric heat to steel refining appears to have been made at La Praz, France, in 1899, by M. Paul Heroult, a well-known French metallurgist. M. Heroult, in the years 1886—88 had worked out the details of, and had patented a successful electro-metallurgical process for the production of aluminium, and at the date named he had already seen this process develop into the basis of a successful industry. It was, therefore, natural that he should attempt to apply the knowledge and experience gained in the period 1888—96, to other branches of metallurgical industry. An electric furnace for the manufacture of ferro-alloys was first designed, and was applied with success to the production of

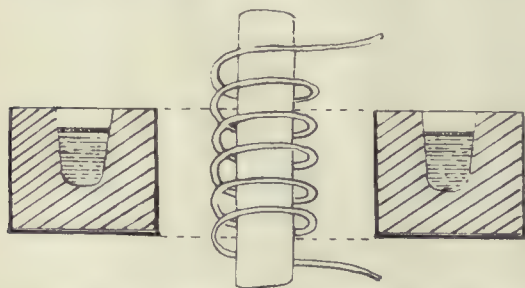


FIG. 4.—DIAGRAMMATIC SECTION OF A SIMPLE INDUCTION FURNACE.

ferro-chrome, ferro-tungsten, ferro-silicon, and other similar alloys.

In 1899 and 1900 Heroult designed and put into operation at La Praz his first furnace for refining steel by aid of electric heat, and about the same date, Keller, another French metallurgist (at Livet) and Stassano, an Italian army engineer (at Rome) commenced similar trials with the types of electric furnace which they have since patented and developed.

The next few years witnessed a great rush of activity in the designing of electric furnaces for the iron and steel industry. The Patent Office files of all countries bear witness to the number and fertility of inventors in this new field of applied electro-metallurgy. For the reasons already stated in the previous article, the majority of these inventions have failed to bring their patentees any credit or pecuniary reward, and the number of different types of electric steel refining furnace, in successful operation at the present day, can be numbered on the fingers of one hand.

It is the opinion of many authorities that future improvements and developments will occur in connection with details of furnace working and control, rather than in any alteration of the broad lines of furnace design. The improvement of electrodes and their holders, and the discovery or manufacture of

more durable refractory materials for furnace linings, are the most pressing needs of the moment.

Cost of Electrodes.—With regard to the first of these, the cost of electrodes is still a very serious item of the total refining charges, and any improvements that would lengthen their life or cheapen their first cost, would prove of great benefit to the electric iron and steel industry. Although graphite is a better conductor than carbon, and electrodes of graphitised carbon are the more durable, ordinary carbon electrodes, on account of their greater cheapness, are employed usually for electric furnace work.

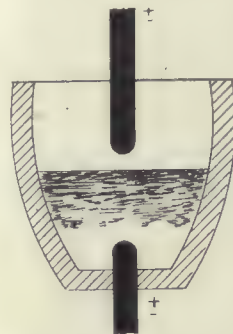


FIG. 5.—SIEMENS' ORIGINAL CRUCIBLE FURNACE.

They are made for the iron and steel furnaces, up to 24 in. in diameter, and 72 in. in length, and a round section has been found to give more economical results than the square shape formerly used. A method of jointing carbon electrodes has also been introduced, which avoids the formation of and losses arising from butt ends. It is quite possible, however, that some substitute for the ordinary carbon electrodes may be found; for carbon has one great defect for electric furnace work, namely, its great affinity for oxygen, and the constant wasting away which occurs, by its combination with this gas, both inside and outside the furnace. The fact that this slow wasting away of the carbon at the point where it enters the furnace roof can be minimised by water-cooling does not altogether surmount the difficulty for the water-cooled carbons abstract heat from the furnace. Water-cooling, though generally practised as the lesser of two evils, thus leads to a direct loss of heat. Furnaces of the resistance type of course escape this problem of carbon electrodes; but as pointed out above, these

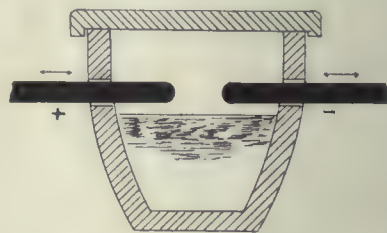


FIG. 6.—SIEMENS' ORIGINAL CRUCIBLE FURNACE (ANOTHER FORM).

furnaces have some difficulty in attaining and maintaining a temperature which permits of rapid and efficient refining of impure raw materials.

In this connection, the suggestion contained in Siemens' Patent Specification, that the material being fused might be employed as electrode material, is worthy of consideration. The history of the electric glow-lamp is not without interest for electro-metallurgists, and if fine wires of tungsten, tantalum and other metals have replaced

the carbon filament in glow-lamps, it is perhaps not indulging in a vain hope to expect and believe that, sooner or later, a solid or molten *metallic* conductor may be discovered, suitable for electric furnace work. The design of the Girod and Chaplet furnaces, indicates how carbon can be dispensed with in steel-refining for the lower electrodes of the furnace; and the problem is therefore now reduced to the discovery of a metal or material suitable for the upper electrode of arc furnaces.

Refractory Linings.—As regards the refractory materials used for the hearths, linings, and roofs of furnaces, the magnesite and silica bricks used at present have not proved entirely satisfactory, and electric steel makers are on the look-out for, and are quite prepared to give a fair trial to any refractory material suitable for their purpose that may prove more durable and can be produced at a reasonable cost. At the moment, no satisfactory substitutes for tamped magnesite and tar or silica are known, but trials are about to be made with an electrically-fused alumina brick, for which high claims are made. Whether the new "Alundum" bricks will stand the combined attack of these powerful physical and chemical forces, remains to be seen.

Electricity Supply.—As regards the question of electricity supply, the tendency is more and more towards the use of alternating current (either single-phase or three-phase) for electric furnace work. The construction of large dynamos is simplified, and the danger to the workers is considerably minimised, when three-phase current is generated—and as the modern tendency is all in the direction of large generating units, electric furnace designers have many sound reasons for adapting their needs to the requirements of the generating stations. In the majority of installations the iron and steel furnaces are provided with their own power stations, operated either by water, or by the waste-gases from blast-furnace and coke-ovens. In Sheffield and in a few other centres steam power is employed for generating the current required.

Chemistry of Refining Process.—Concerning the chemistry of the refining process, it must be clearly understood that no electrolytic action occurs in the furnace, and that the effect of the electric current is simply of a thermal character. The refining action is due to the washing out and removal of sulphur, phosphorus, etc. by the aid of suitable slags.

Power Statistics.—Table I. contains a summary of figures collected by the author and published in 1907 in the handbook already referred to. Table II. contains figures compiled by Victor Engelhardt, and published in an article contributed to the *Zeitschr. Vereines Deutsch. Ing.* on November 19th, 1910, while Table III. contains figures for power consumption collected by the author and based on the most recent returns.

A comparison of these three sets of figures with each other will indicate the progress that has been made in electric steel refining between 1907 and 1912.

TABLE I.

Kw. hours required for the production of 1 ton (2,000 lbs.) of iron or steel, in different types of furnace (Kershaw, 1906).

	I. <i>Heroult.</i>	II. <i>Keller.</i>	III. <i>Stassano.</i>	IV. <i>Girod.</i>
Steel from scrap and pig (cold)	864	730	1,164	1,136
Steel from scrap and pig (hot)	329	631	—	—
Pig iron from ore, coke and lime (cold) ..	2,693	2,292	—	—
Steel from ore, coke and lime (cold)	—	2,800	2,804	—
Nickel pig from ore ..	2,342	—	—	—

TABLE II.

Kw. hours necessary for the production of a ton (2,204 lbs.) of iron or steel, in a Röchling-Rodenhauser Furnace (Engelhardt, 1910).

Pig-iron direct from the ore	2,000 kw. hrs.
Steel direct from the ore	3,000 "
Steel from cold pig-iron	1,500 "
Steel from liquid pig-iron	1,100 "
Steel from cold pig and cold scrap ..	700 "
Steel from liquid pig and cold scrap ..	600 "
Steel from cold scrap	900 "
Refining molten open-hearth steel for special tool steel	250 "
Refining molten open-hearth steel for rail steel	120 "
Maintaining heat in a casting ladle ..	50 "

The actual costs of production, when working under various conditions as regards raw materials, are given by Engelhardt for a 5-ton Röchling-Rodenhauser furnace, as follows:—

Steam-power.—From 94.5 marks to 123.3 marks per ton.

Water-power.—From 78.6 marks to 96.1 marks.

The cost of the former is taken at 5 pfg. (or three-fifths of a penny) per k.w. hour; and of the latter at 2 pfg. (or one farthing) per k.w. hour.

TABLE III.

Power consumption in kw. hours per metric ton (2,204 lbs.) of steel produced (Kershaw, 1912).

Name of Furnace.	Cold Charges. Average.	Hot Charges. Average.
Heroult	493	146
Girod	800	237
Stassano	900	—
Kjellin	747	—
R. Rodenhauser	773	214
Keller	—	275
Frick	790	—
Hiorth	700	—
Colby	715	—

THE TINNING INDUSTRY FROM A CHEMICAL STANDPOINT.

By HERBERT H. HODGSON, M.A., B.Sc., Ph.D.

OWING to the easy access of tin ores in nature, this metal has for ages been put to useful service. The tin mines of Cornwall, for example, have been worked since very early times, while tinning itself, *i.e.*, the coating of objects with tin, is one of the arts handed down from antiquity, since the tinning of brass and copper was well known to the Romans.

Originally serving for the production of ornamental articles, such as warlike implements, headgear and incrustated silver, tin became of extraordinary importance for the preparation of various kinds of bronze objects. As in the case of the enamelling industry, the art of tinning has evolved from being entirely ornamental, until its application to sheet iron and later to basic steel transformed the erstwhile art into the great tin-plate industry.

The usefulness of this craft not only lies in the fact that black iron acquires a beautiful lustre, but also that it is protected from rust, while copper is preserved against verdigris; consequently the tinned utensils made from the above metals may find manifold use in a place like the kitchen, being employed with advantage where the free metals would prove injurious.

At first tinning was practised as an auxiliary branch of various handicrafts, such as that of the copper-smith, spur-maker, etc., but its rapid development brought about its separation as an individual industry. As early as 1670, an English company was formed to start a tin-plate works at Pontypool, but patent difficulties occasioned their stoppage. In 1720, however, works were started once more at Pontypool, and, being followed by others in South Wales, the industry developed so extensively as to become the most important seat of this manufacture in the world.

It is interesting to note the part played by the chemist in what is apparently a non-chemical industry.

All iron intended for tinning has first to undergo pickling, scouring, and cleaning, since the smallest impurity suffices to prevent the tin from adhering. The tin therefore must be carefully purified at the outset. The pickling process has exercised the minds of those engaged in the industry from its commencement, and the problems it presents are essentially of a chemical character. The real development of tinning, therefore, runs parallel with that of the production of mineral acids and sheet steel.

The object of pickling is to remove the adhering oxide layer from the iron. As a preliminary process, the sheet iron was formerly dipped into ammonium chloride solution, next heated to redness and while red-hot plunged into water. Layers of magnetic oxide of iron readily fall off after this treatment, while the penetration of nascent ammonia and hydrogen produce an internal loosening force. A part of the chlorine also is fixed as hydrochloric acid on the iron surface, thereby accelerating chemical

solution of the oxide layer on subsequent immersion in water. Pickling was originally performed with organic acids, some of which were produced by the fermentation of substances like meal, poor milk, acidified potato-paste, etc. These were employed cold at the beginning, but later in a warm condition.

Pickling recipes constituted a typical works' secret, and firms were inclined to pride themselves upon the excellence of their pickling agents. It is interesting to note that Réaumur, the famous French chemist and physicist, was the first to recommend dilute sulphuric acid for pickling sheet iron.

At the present time the sheets are very carefully dipped into a mixture of dilute sulphuric and hydrochloric acids, then well washed, dried, and gradually heated to a cherry-red heat in iron boxes placed in furnaces. After remaining several hours in the furnace, the sheets are slowly cooled and smoothed between hard rollers, again rapidly heated with exclusion of air, and dipped once more into a fermenting mixture of bran and water. A final dip in dilute sulphuric acid with subsequent washing and sand scouring, causes the sheets to be ready for the plating process. It is worthy of note that the early observation of the favourable effect of chlorine upon the utensil to be tinned has been confirmed and utilised in the modern process, and it is such points as these which illustrate most effectually the value of the industrial chemist.

Until government action was taken, lead was formerly added to the fused tin for easier tinning, and we find that Newton proposed the addition of bismuth for rendering the tin more fusible.

The actual tinning apparatus or stow consists of five vats; the first and fifth, known as the grease pots, contain tallow or palm-oil; the second, called the tinman's pot, is filled with ordinary molten tin at 400° C., this being covered with a layer of palm oil to prevent oxidation. The sheets are placed in the grease pot while wet, and after 10 minutes are taken to the tinman's pot.

Small metallic objects are, however, usually tinned by the blanching process. The well-scrubbed object is placed for several hours in a boiling solution containing granular tin or alkali stannates. The object is then washed with water, rubbed, and dried.

In the fat-tinning process, specially prepared beef tallows and other similar preparations were formerly used in place of palm-oil. Réaumur, who appears to have investigated the tinning process with some thoroughness, discovered that the part played by the fat was not exhausted in merely preventing oxidation, but that under certain conditions this promotes the smoothness and uniformity of the tinning in an extraordinary way. He observed that a tin bath, which was already cooled down so far that an iron sheet coated with blackened beef tallow was not tinned further, was still in a condition to tin a sheet covered with resin, that on further decrease of temperature the tin bath refused the resin, but that a sheet covered with wax still accepted tin, while on further cooling an iron sheet powdered with sal-ammoniac could still be tinned. From this short

notice will be gathered how the tinning process bristles with problems of a chemical and physical character; others, such as temperature conditions, *e.g.*, by tinning above 235°C . the objects on cooling acquire a yellowish tint, could be mentioned, but space will not permit.

Electro-tinning has recently made important progress although as yet no marked commercial success has been attained. One such process proposed depends on the use of a stannous chloride solution with addition of alkali and sodium pyrophosphate as electrolyte, a tin-plate being employed as electrode. With the growing interdependence of chemistry and electricity, it seems reasonable to anticipate a successful future for such processes as the above.

The economic side of industries which require tin is exhibited by the remarkable rise in the price of tin during recent years. Two causes appear to contribute, *viz.*, the abnormal demand for tin, and the fact that the cheaper open workings have become almost exhausted and have had to be abandoned for the more expensive mining.

This rapid increase in price has resulted in a whole series of proposals for recovering tin from waste articles. That such would be attempted may readily be gathered when it is realised that France annually consumes 80 million tins of anchovy, Switzerland over 70 millions for the export of condensed milk, while the number of preserve tins annually consumed in America is estimated at 700 millions.

In practice the prospect of remunerative treatment is less bright than would appear on the surface. The waste tins have to be collected from dust bins, rubbish heaps, etc., where the supply is not only apt to be uncertain, but when obtained necessitates laborious treatment in order to be freed from the miscellaneous dirt with which the tins are covered.

Most of the proposed methods have therefore been devised to deal with the scrap at tinning works. The stripping processes have been classified into acidic and alkaline, and are electrolytic in character since purely mechanical or chemical processes have yielded but indifferent results. One chemical process, however, first employed at Metikon in Switzerland, deserves special mention, since by it the tin is transformed into tin tetrachloride by means of electrolytic chlorine and thus collected as a fuming liquid.

Acid processes, in which the tin is made the anode in an electrolyte of dilute acid, usually H_2SO_4 , and thence received on lead or copper cathodes, have the unfortunate drawback that the tin dissolves less readily than the iron, and as soon as the latter becomes exposed its dissolution proceeds with the greater rapidity filling up the bath with ferrous sulphate. The exposure of the iron has also the effect of protecting the remaining tin, so that the iron scrap being imperfectly stripped has its own low value still further diminished.

The alkaline processes afterwards devised, possess the great advantage of permitting the use of an iron receiver for the electrolyte and a basket made of iron

wire for holding the tinned waste. The receiver is not only unattacked by alkalis, but the tinned waste stands in better electrical connection with the current conductor. A disadvantage, however, lies in the circumstance that the stannates formed are somewhat unstable, and, when exposed to air, are apt to deposit their tin as oxide through the action of atmospheric carbon dioxide.

Where tin is recovered from lead scrap the above difficulties are not encountered, since, unlike iron, lead is electro-negative to tin, and on making scrap tin the anode in an electrolyte of H_2SO_4 , the tin dissolves, leaving the lead unattacked.

PERSONAL AND OTHER NOTES.

MR. GEORGE A. WILLS and Mr. Henry W. Wills have offered £150,000 to the Council of Bristol University in order that the site adjacent to the present buildings should be utilised for a building containing a large hall, libraries, council chamber, lecture rooms, and main entrance. Mr. W. Melville Wills, of the same family, also offers £20,000.

In the House of Commons on February 7th, Mr. Lloyd George was asked if he would guarantee a loan to stimulate the sugar beet industry in this country on the same terms as £3,000,000 had been guaranteed for the cotton industry in the Sudan. He replied that he could not recommend Government assistance on the lines suggested.

Lord Iveagh has decided to plant 25—30 acres of his Suffolk estate with tobacco. Mr. J. C. Wallis, of Peterborough, one of the pioneers of tobacco growing in this country, has given a record order for seed for this year's crop.

An anonymous donor has offered to the Council of Cambridge University the sum of £10,000 for the permanent endowment of a Chair in astrophysics, on condition that the University raises the total emoluments of the Chair to £800 a year. The Council recommend that the offer be accepted, and that the Chair of astrophysics take the place of the Plumian professorship of astronomy, vacant by the death of Sir George Darwin.

Science reports that by the will of the late Alfred Samson, who recently died at Brussels, the following bequests are made to science:—£100,000 is bequeathed to the Prussian Academy of Sciences, and £20,000 is bequeathed to the Bavarian Academy of Sciences, at Berlin and Munich.

The death is announced of Mr. George Matthey, F.R.S., Vice-President of the Royal Institution in 1896 and a member of the French Legion of Honour, which took place on February 14th, at Eastbourne, in the eighty-seventh year of his age.

We regret to announce the death of Dr. G. A. Koenig, Professor of Chemistry at the Michigan College of Mines. Born in 1844, he was educated at the Universities of Heidelberg and Berlin. He went to America in 1868, and held an appointment at the University of Pennsylvania, afterwards joining the Michigan faculty.

NOTES ON CHEMICAL ENGINEERING.

By J. W. HINCHLEY, A.R.S.M., WH.Sc.

CHAPTER I.—*Continued.*

SIZE-REDUCTION OF SOLID MATERIALS.

REDUCTION in size by means of tube mills may take place in three distinct ways, and the extent to which any method predominates is determined by the conditions. The balls may crush the material by rolling upon the lining and on each other; by impact, through the projection of the balls after being lifted by the rotation of the mill; and by grinding, through the sliding of the balls on the lining and on each other. In dry working with a smooth lining the work done by the mill is very much reduced, but as soon as the surface of the lining becomes roughened the balls are lifted and the rate of working immediately improves. In dry grinding,

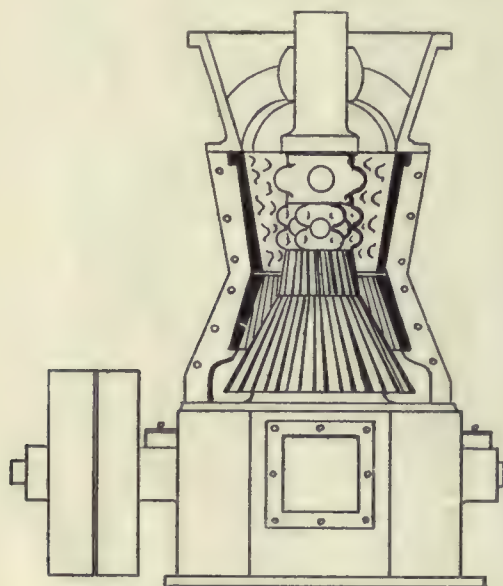


FIG. 9.

impact action is therefore important, but when grinding wet the intensity of the blows must be much reduced by the water, and it would appear that crushing by rolling would be more prominent. But in wet grinding ovoid pebbles usually produce distinctly better reduction and a higher efficiency, although in dry working the reverse statement is true. For dry reduction, therefore, the tube mill should be treated as a crushing machine, and for wet reduction as a grinding mill. The size, shape and density of the balls, the volume they occupy, and the speed of rotation all have a distinct effect on the proportions in which the different actions take place. The noise which is produced by the action of the mill is the best working indication of its action. The best speed for dry reduction is usually about 10% higher than that given by Davidsen's rule and

that which is satisfactory for wet working. The volume occupied by the pebbles should be from .50 to .55 times that of the tube, fresh pebbles being added through the manhole from time to time as the old pebbles are reduced in size and discharged from the machine. A perforated plate at the discharge end of the machine allows the pebbles to be discharged when too small for effective work. The volume of pebbles may, with advantage, be greater for wet than for dry reduction, and also when the very finest grinding is required; for rough work, the volume of pebbles may be somewhat less than given by the rule.

The shells of these mills are usually built up of steel plates, $\frac{3}{8}$ in. to $\frac{5}{8}$ in. thick, and, in perhaps the most efficient size, viz., 15 to 20 ft. by 4 ft. diameter the plates would be $\frac{1}{2}$ in. thick. The shells are either rotated on trunnions at each end, through which the feed and discharge takes place, or circular rings may be provided to run upon rollers; the latter method

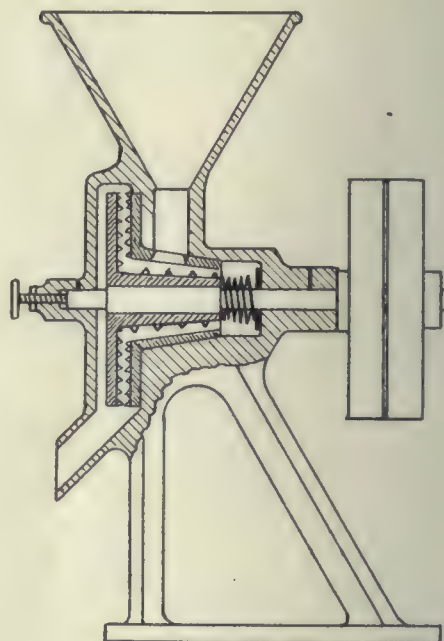


FIG. 10.

is the most economical of power, unless anti-friction devices are provided on the trunnions.

The discharge in some mills is made from perforations in the shell at the periphery, but this method is not so satisfactory as axial discharge.

Grinding Machines.—Size-reduction machines which act mainly by grinding, or by subjecting the material to shearing stresses, do not offer so many variations of type as crushing machines, but an additional factor often appears—the adhesion of the material to the grinding surface.

Coarse Grinding Machines.—These machines consist of a toothed or grooved surface, which moves past a similar fixed surface. The surfaces may be cones, discs or cylinders, or combinations of these forms. For coarse work alone, except when treating soft materials and grain, such machines are not efficient in power, but, owing to the production of a uniform small size, are extremely useful in many classes of work. A conical machine for heavy work (Fig. 9) is made, capable of reducing rock at one operation to $\frac{1}{8}$ in. size at the rate of over 15 tons per hour. Such machines are made in all sizes down to the ordinary domestic coffee or pepper mill. For the enormous range of reduction these machines are remarkably efficient, but they are not suitable for quartz or materials of greater hardness. The wearing surfaces, which are renewable of necessity, are of chilled cast-iron, and can be rapidly replaced. On account of their low first cost, ease of management, and range of usefulness, these mills are popular for limestone, graphite, steatite, gypsum, etc. In such machines

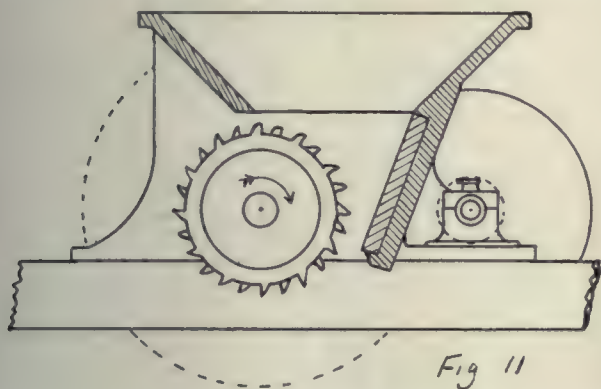


Fig. 11

one-horse power per hour is capable of reducing 10 cwts. of standard limestone to $\frac{3}{16}$ in. size.

Disc machines (Fig. 10) for medium grinding are in common use for comparatively soft materials—grain, charcoal, cake, etc.

Roller machines of similar character, in which a toothed or grooved roller forces the material past a fixed jaw (Fig. 11), are commonly used for breaking down clay and similar compact materials.

Modifications of these machines are obtained by providing a differential movement to both surfaces, with the advantages of more even wear and definite feed. Conical machines modified in this way are well known for kibbling, or reducing to meal, cereals, etc.

The disc mill is usually modified by placing one of the discs out of centre and allowing it to be rotated by the grinding action between the two. By this means the material travels radially across the concentric grooves or teeth in the discs and is broken up by simple shearing actions, and the surface friction of the fixed disc type is avoided.

Roller mills are similarly modified by substituting a rotating toothed roller for the fixed jaw (Fig. 12), and gearing the two rollers together in a velocity ratio of about 3:1. By reciprocating one of the

rollers longitudinally a further useful modification is obtained in that the wear on the rollers is equalised to some extent.

In all coarse grinding machines adjustments are provided so that the toothed surfaces cannot come into actual contact, while, in fine grinding machines, it is common to allow this to take place, the pressure between the grinding surfaces being adjusted rather than their distance apart.

Fine Grinding Machines.—All types of coarse grinding machines are also designed for fine grinding

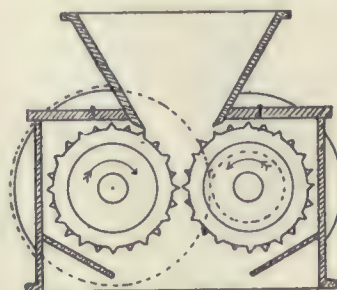


Fig. 12.

by the provision of suitable grinding surfaces and arrangements for their adjustment. The workmanship must, however, be of the highest class for satisfactory results.

Most of the fine grinding in the chemical and spice trade is done on millstone mills (Fig. 13). The grinding surfaces are horizontal discs or millstones, one of which, either the upper or the lower, is fixed, and the other rotates concentric with it. The material is fed through a central hole in the upper stone from 8 ins. to 10 ins. diameter. The stones are usually French buhr, built up and sup-

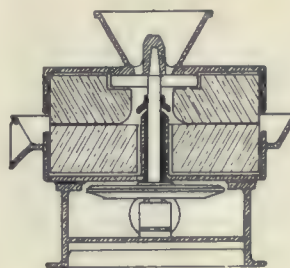


Fig. 13.

ported on a backing of suitable cement or plaster. Other stones, such as granite, marble or stoneware, are used for grinding special materials. Such mills, although slow, are excellent for general work, but for the finest grinding are difficult to keep in perfect order. Furrows, about $\frac{1}{2}$ in. deep and 2 ins. wide are cut in each stone oblique to the radius, so that the particles of material are driven to the periphery of the stones, and at the same time cut by the sharp edges of the furrows. The rotating stone, the upper one in Fig. 13, is driven by a spider and balanced by placing weights in recesses in its upper surface. The usual peripheral speed of such mills is 1,500 ft. per minute, but with well-built and balanced stones a

speed of 4,000 ft. or more may be safely used with corresponding increase of output. The heating of the material, or the stone producing damage to the product, or cracking in the stones, fixes the limit when the engineering work is satisfactory. When driven at a peripheral speed of 1,500 ft. per minute, the horse-power required for reducing standard limestone from $\frac{1}{4}$ in. size to 60 mesh is approximately one and a half times the diameter of the stone in feet, and the output under the best conditions will be 2 cwts. per horse-power-hour. Granite stones are best for unctious materials, such as steatite, graphite, etc., and also for soft substances. The amount of wear near the periphery is much greater than near the centre of the stones, and on this account they

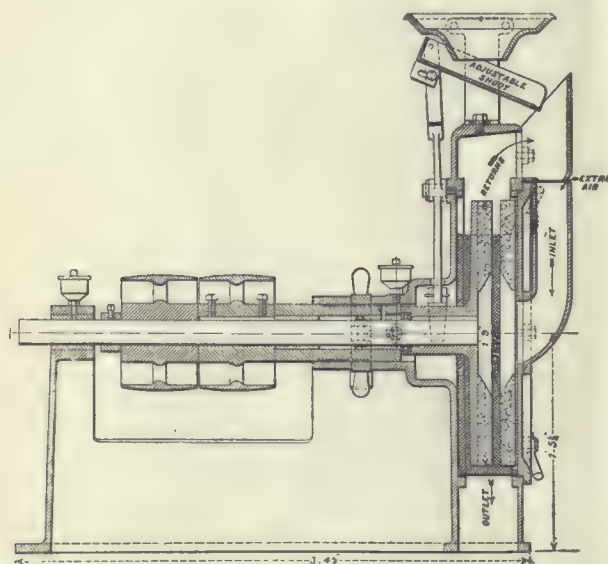


FIG. 14.

should be dressed slightly hollow, and, as soon as the outer surface ceases to grind, re-dressed. This operation is usually necessary every fourteen days, and makes a serious repair bill.

The use of built-up stones of rock emery has made these mills capable of much higher efficiency and output, and avoided nearly all the usual dressing operations. The centre of the stone is built up of buhrstone, and the periphery only of rock emery; no furrows are made in the emery grinding face, but slabs of sandstone are inserted radially and may be cut or serve the same purpose. The whole of the stones making up the millstone are held together by pouring molten metal, such as zinc, between the joints. Such stones can be run at very high peripheral speeds, 5,500 ft. per minute, without fear of cracking or mechanical fault, and rarely need dressing. By the use of such stones the mills become suitable for reducing the hardest materials by grinding.

Similar mills are also made (Fig. 14) with horizontal shafts and vertical grinding surfaces, which are more compact and convenient for many classes of work. The illustration shows an oscillating shoot to feed the material between the stones, the discharge taking place through the screen.

Although all grinding machines have some advantage over crushing machines in the greater uniformity of the product, sifting devices are occasionally provided, as in Fig. 14, by discharging the product through a screen concentric with the stones, while

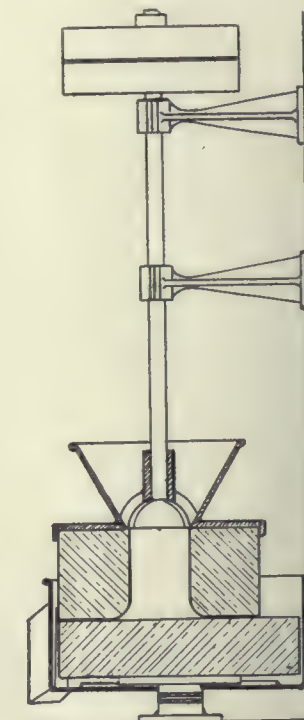


FIG. 15.

paddles fixed on the rotating stone lift the coarse material back to the feeder.

By using stones of different sizes, one of which is driven eccentrically to the other, which is mounted freely on a footstep bearing, the grinding becomes radial as in the similar coarse grinding machines, and the stones grind each other true.

The vertical eccentric mill (Fig. 15) is a good example, and is used for paints, black lead, chalk, crayon and pencil masses. The upper stone only is driven, and rests with its weight on the lower stone. It is usually used as a wet grinding mill and, except for the charging of the rotating hopper, needs little attention.

(To be continued.)

CORRESPONDENCE.

(The Editor will be pleased to publish letters dealing with subjects which may be of general interest.)

Synthetic Ammonia.—A recent paper by Haber and Rossignol in *Z. Electrochem.* (1913, 19, 53), gives some interesting particulars concerning this new industry. Osmium and uranium will act as catalyst at 500°—700°. A continuous method of working is necessary to commercial success. Interesting details are given of apparatus used for experimental work on relative efficiency of catalysts.

REVIEWS OF BOOKS.

"THE PRINCIPLES OF APPLIED ELECTRO-CHEMISTRY." By A. J. Allmand. EDWARD ARNOLD, London, 1912. Pages 547 + vi., including Index and Appendices. Chapters XXVIII., including 136 Illustrations. Price 18/- net.

THERE are few branches of applied science in which technical success is so intimately connected with a theoretical understanding of the processes involved, as in applied electrochemistry. Consequently there is an exceptional need in this province for a book which would describe accurately the scientific foundations of the subject, and proceed to show how they can be utilised in the cause of industry. It happens that hitherto the main works dealing with applied electrochemistry include only an inadequate, often an unsound, treatment of the theory of the science; moreover they are, in most cases, at the present time, scarcely up-to-date in their description of manufacturing processes. The theoretical text-books, on the other hand, completely neglect the utilitarian side of the subject.

In the work under review, Mr. Allmand has fulfilled a very real want by producing a book, which, in its first part, gives a progressive account of theoretical electrochemistry, and in the second, a study of the employment of electrochemical methods in industrial processes. The volume appeals to students as well as to technical men, and in fact quite the best part of the work is to be found in the theoretical portion. Nevertheless, as far as may be, mathematical calculations have been excluded, and a knowledge of the differential calculus on the part of the reader is not assumed. Where algebraic formulæ are introduced, simple numerical problems, of a kind that often occur in practice, are given to illustrate their application; this is worth more than many pages of explanation. The author has evidently endeavoured to make the best use of his space, and there is less vain repetition and purposeless discussion than is often met with in books of this class.

Part I. opens inevitably with a description of the matter common to all the branches of physical chemistry. This is well executed. Coming to electrochemistry proper, the author discusses the conduction-phenomena of electrolytes. Here it is curious that he makes no mention of the "visible" methods due to Lodge and Whetham, of following the movement taking place in a solution through which current is passing, although such methods would specially appeal to the technical man. The ionic theory is next outlined, in a way perhaps not quite adequate to the occasion. For, since the theory is made the basis of expression of electrochemical change throughout the book, it would have been justifiable to devote some space to the real facts on which the theory is supported, and to survey the genuine—as opposed to the purely

fanciful—objections which have been raised against it. It must be added that all through the book the facts seem to be expressed in rather too exclusively ionic language. And it may thus happen, that ideas and reactional equations which are perfectly familiar to some of the technical readers, may yet pass unrecognised by them in the forms in which they are printed. The chapters showing the relation between the energy change of a chemical reaction and the E.M.F. which can produce or be produced by the reaction are extremely satisfactory. This is doubly valuable, because the connection between these quantities is of the first importance to industrial electrochemistry, and because it is on this part of the subject that previous books have usually failed. The general nature of electrochemical reactions which can take place at the kathode and anode are then considered separately. This method of individual treatment of the changes occurring at a single electrode would, if it became popular, render impossible much of the loose reasoning that is sometimes indulged in by writers on applied electrochemistry. The distinction is emphasised between reversible and irreversible effects, the dependence of irreversibility upon the insufficient reactional velocity of part of the electrode-process being pointed out. These notions find their logical application in the two excellent chapters on primary and secondary cells, with which the second part of the book opens.

Considered as a whole, however, the second portion of the book (dealing with the application of principles described in the first half), there seems a certain break between theory and practice. It is true that a large portion of the section dealing with each industry is given up to the theoretical discussion of the alternative changes which can occur at each electrode, and the conditions suited for the attainment of high current efficiency—and this is of value. There is but little general discussion of the factors governing the magnitude of the minimum voltage at which any process can work. Thus in describing the copper-winning processes, using insoluble anodes, the theoretical decomposition E.M.F. in one case certainly is worked out. But a single calculation of this kind is of less instructive value than the simple statement that it follows from first principles, that processes of the Hœffner and Siemens-Halske type ought to work at lower voltages than those similar to the Keith process; for the former utilises the reducing energy contained in any copper sulphide ore, and the latter do not. Again, in the Castner process for making caustic alkali, theoretical considerations would lead us to expect that it is only when the concentration of sodium in the mercury in both compartments of the cell is kept equal that the cell will begin to work at the

E.M.F. at which it would begin to work, supposing the mercury intermediate electrode were not present. Yet this is not mentioned, although it is just the impossibility of keeping the sodium concentration uniform that makes the energy-efficiency of the Castner rocking-cell so low. This point is only pointed out here because the excellent treatment of the principle of decomposition potentials in the first part of the book led one to hope that the idea would be more fully utilised in the description of industrial processes. The industrial processes themselves, however, are well described, and the account given corresponds more to the actual present-day state of the industry than that to be found in books published five or ten years ago. The various abandoned processes of copper-extraction are examined at length, while the only one which is now being worked on a large scale is quite briefly discussed. In the case of tin-refining, on the other hand, the various processes which have merely historical interest are rightly omitted, and a valuable summary of Fœrster's recent researches on the anodic solution of that metal is given.

In a useful series of chapters on electric furnaces and their products, the author succeeds in giving the main features of the principal furnace-types, while omitting the mass of constructional details which would interest only the engineer. Sections on the electrolysis of fused salts occur in both theoretical and practical parts. The chapters on the oxidation of nitrogen are of special interest since Mr. Allmand is known to have worked under Haber, and supports, with conviction but not without fairness, his view that the oxidation is an electrical, not a thermal process. The technical processes of nitrogen-fixation are described quite shortly.

The author acknowledges his indebtedness to Fœrster's "Electrochemistry of Aqueous Solutions," and Fœrster's researches in various directions are described with the fulness that they deserve; but they might reasonably be treated a little more critically, for at least in the case of the passivity of iron there is experimental work on record which, if confirmed, would seem to make the unmodified Fœrsterian view untenable.

To summarise, all interested in electrochemistry ought to be extremely grateful to the author for the production of the book.

U. R. E.

"INORGANIC CHEMISTRY FOR BEGINNERS." By Rt. Hon. Sir Henry Roscoe and Joseph Lunt. MACMILLAN & Co., London, 1912. Pages 256 + x, including Index and Appendix. Divided into two parts, with numerous Illustrations. Price 2/6.

This small work was first published in 1893, and at once obtained recognition as one of the most popular of the elementary text-books. The second edition which has followed, after many reprints and corrected first editions, has still certain satisfactory features which will attract the attention of teachers of elementary science. The illustrations are numerous, and of such a nature that they act as a direct aid to the experimental treatment of the

subject-matter dealt with. This edition is likely to meet with success, under the altered conditions existing to-day, which are altogether different to those under the old Science and Art Department *régime*, when this work received such attention from both masters and students.

"MODERN RESEARCH IN ORGANIC CHEMISTRY."

By F. G. Pope. METHUEN & Co., LTD., London, 1912. Pages 324 + xi, including 2 Indexes. Chapters IX., with 261 Diagrams. Price 7/6.

This is an exceedingly interesting volume and one which can in every way be recommended to the student. The work is divided into sections, and deals with the results of certain investigations in connection with the chemical constitution of the polymethylenes, terpenes and camphors, the alkaloids, pyrones, ozonides, purines, etc. The question of the relationship between colour and constitution, salt formation, and pseudo-acids and bases is considered in a satisfactory manner. There can be no doubt but that this work will serve a very useful purpose and that it will command attention from those who are engaged in teaching organic chemistry under modern conditions.

"THEORIES OF SOLUTIONS." By Svante Arrhenius.

HENRY FROWDE, London, 1912. Pages 247 + xi, including Bibliographical References and 2 Indexes. Lecture XI., with Diagrams. Price 12/6 net.

This work is based on a series of lectures delivered by the author at Yale University in 1911. As may be expected it gives a useful account of modern progress in this direction. The book opens with a short history of the theory of solutions with an account of Gore's and Hittorf's experiments.

This is followed by a chapter on the modern molecular theory, including an account of the work of Perrin, Svedberg, Ostwald, and others. Such subjects as suspensions, absorptions, analogy between gaseous and dissolved state of matter, electrolytic dissociation, velocity of reactions, conductivity of strong electrolytes, and equilibria in solutions are also dealt with at some length, and in a way which does not involve a difficult mathematical treatment.

This work is beyond doubt a useful one, and will be found to be of value to both the student and general chemist.

"INDUSTRIAL AND MANUFACTURING CHEMISTRY (ORGANIC)." By Geoffrey Martin. CROSBY LOCK-

WOOD & SON, London, 1913. Pages 726 + viii, including Appendix and Indexes. Divided into XXIII. Sections, with 249 Illustrations. Price 21/- net.

This work deserves to receive the careful attention of all those interested in chemistry. It represents an ambitious attempt to include within some 700 pages an account of modern industrial chemistry. It is claimed that this work will serve as both a text-book and also a work of reference. We think, so far as a work of this compass can achieve such an end, that the claim is justified. It would always be possible to point to sections in a work of this nature which are not so fully treated or so satisfactory as others, yet it must be acknowledged

that this work does not suffer in this respect to an appreciable extent.

The editor and publisher are to be congratulated on the production of a work which bears evidence of such careful and thorough production. It is not possible to mention the many subjects dealt with in the twenty-three sections into which this work is divided, but it may be said that these cover most of the more important industries which owe their origin or present position to chemical science.

BOOKS RECEIVED.

"Industrial Chemistry." A Manual for the Student and Manufacturer. Edited by A. Rogers and A. B. Aubert. Constable & Co., Ltd., London, 1912. Pages 854 + xiv, including Index. Chapters XLIII., with 340 Illustrations. Price 24/- net.

"The Plant Alkaloids," by T. A. Henry. J. & A. Churchill, London, 1913. Pages 466 + vi, including Appendix and Index. Chapters IX. Price 18/- net.

"Organic Chemistry," by James F. Norris. Hill Publishing Co., Ltd., London, 1912. Pages 579 + vii, including Index. Chapters XXXI. Price 10/6 net.

"Inorganic Chemistry," by H. P. Cady. Hill Publishing Co., Ltd., London, 1912. Pages 629 + vii, including Index. Chapters XXXI., with 42 Illustrations and Frontispiece. Price 10/6 net.

"Leather Chemists' Pocket Book." Edited by H. R. Procter. E. & F. N. Spon, Ltd., London. Pages 223 + xiv, including Index. Chapters XV., with 4 Illustrations. Price 5/- net.

"Electrical Symbols for Mine Maps," by H. H. Clark. Technical Paper 22, Bureau of Mines, Washington, U.S.A. 1912. Pages 11, with 8 Figures.

"Mine Fires," a Preliminary Study, by George S. Rice. Technical Paper 24, Bureau of Mines, Washington, U.S.A., 1912. Pages 51, including Index and 1 Figure.

"Methods of Determining the Sulphur Content of Fuels, Especially Petroleum Products," by Irving C. Allen and I. W. Robertson. Technical Paper 26, Bureau of Mines, Washington, U.S.A., 1912. Pages 13, with 1 Figure.

"Ignition of Gas by Standard Incandescent Lamps," by H. H. Clark. Technical Paper 28, Bureau of Mines, Washington, U.S.A., 1912. Pages 6.

"Methods for the Determination of Water in Petroleum and its Products," by Irving V. Allen and Walter A. Jacobs. Technical Paper 25, Bureau of Mines, Washington, U.S.A., 1912. Pages 13, with 2 Figures.

"An Investigation of Explosion-Proof Motors," by H. H. Clark. Bulletin 46, Bureau of Mines, Washington, U.S.A., 1912. Pages 44, with VI. Plates and 14 Figures.

"Comparative Fuel Values of Gasoline and Denatured Alcohol in Internal-Combustion Engines," by R. S. Strong and Lauson Stone. Bulletin 43, Bureau of Mines, Washington, U.S.A., 1912. Pages 243 + v, with 3 Plates and 32 Figures.

"Smoke Abatement and City Smoke Ordinances," by Samuel B. Flagg. Bulletin 49, Bureau of Mines, Washington, U.S.A., 1912. Pages 57.

"Monthly Statement of Coal-Mine Accidents in the United States, January to August, 1912," by Frederick W. Horton. Technical Paper 27, Bureau of Mines, Washington, U.S.A., 1912. Pages 23.

NEW METHODS OF ANALYSIS.

THE GRAVIMETRIC ESTIMATION OF NICKEL IN STEELS BY THE DIMETHYLGLOXIME METHOD.

By GEORGE GLENN.

THE method generally used in a steel works laboratory for the estimation of nickel is the cyanometric method, with or without the separation of iron.

In the dimethylgloxime method (see also this Journal, 1912, I, 247), the iron is held in solution with tartrate or citric acid, preferably tartaric, as ferric am. tartrate or citrate, on being made strongly ammoniacal, the iron remains in solution on addition of the reagent, but the nickel will be completely precipitated on adding an excess of the reagent. It can be filtered off and weighed as such, containing 20.32% Ni, or ignited at a bright red heat and weighed as NiO, which contains 78.5% Ni.

The method is as follows:—1 gm. of steel in 10 c.cs. of HCl, oxidised with HNO₃, eliminate the SiO₂ by evaporating, baking, redissolving in HCl, and filtering off the SiO₂. The filtrate is then diluted to about 300 c.cs., 3 gms. of tartaric acid are added, the solution then made strongly alkaline with ammonia, heat to 50°C., add in excess of dimethylgloxime reagent, allow to stand in a warm place with occasional stirring. The precipitate is scarlet. Filter off through pulp, wash well with hot water containing a little ammonium nitrate, and finally wash with hot water.

TABLE I.

Est. No.	% Ni added.	% Ni found.	% Error.	C.cs. of Reagent used.	
				C.CS.	
1	.12	.157	+ .037	10.0	Silicon removed as given in the method, iron held in solution with tartaric acid.
2	.20	.235	+ .035	10.0	
3	.28	.314	+ .034	10.0	
4	.36	.361	+ .001	15.0	
5	.48	.471	— .009	15.0	
6	.64	.628	— .012	15.0	
7	.80	.832	+ .032	15.0	
8	.92	.942	+ .022	20.0	
9	1.00	1.08	+ .080	20.0	Silicon removed by filtration before the second precipitation of the Ni. Iron held up with tartaric acid.
10	2.00	2.04	+ .040	20.0	
11	2.00	1.99	— .010	25.0	
12	2.00	1.96	— .040	25.0	
13	2.50	2.54	+ .040	25.0	Same as 9 to 12. Iron held up with citric acid.
14	3.00	3.06	+ .060	30.0	
15	3.50	3.56	+ .060	50.0	
16	4.00	4.08	+ .080	50.0	
17	2.00	2.041	+ .041	25.0	Same as 9 to 12. Iron held up with tartaric acid.
18	5.00	5.04	+ .04	50.0	
19	7.00	7.04	+ .04	70.0	
20	9.00	9.04	+ .04	80.0	

The pulp and precipitate are now transferred without loss to a tarred platinum dish (covered inside with ashless papers), wrapped up in the filter papers, and cautiously

ignited at the mouth of the muffle until the paper is completely charred.

Proceed by either of the two ways, (1) as NiO; (2) as $\text{NiC}_8\text{H}_{14}\text{N}_4\text{O}_4$.

(1) Increase the temperature and finish the ignition at a bright red, and cool and weigh as NiO = 78.5% Ni.

(2) Carefully burn off the paper pulp at a low heat. cool and weigh as $\text{NiC}_8\text{H}_{14}\text{N}_4\text{O}_4$, containing 20.32% Ni.

Reagent = 5 gms. of the salt in 500 c.cs. of rectified spirits.

To 1 gm. of steel (Ni free), various amounts of a standard nickel solution (4 gms. Ni per litre) were added, with the following results (see Table I.).

From the determinations shown in Table I. it was found necessary to remove the SiO_2 , either before the second precipitation of the Ni, or in first opening out, as given in the method; if the latter is done, and providing an ample excess of reagent has been added, only one precipitation will be found necessary.

The above were all weighed as NiO.

No. 17 is a determination on bare solutions in order to find a blank on acids and reagent used, and gave a blank of .041% Ni.

COMPARISON OF THE VOLUMETRIC CYANIDE METHOD AND THE GRAVIMETRIC DIMETHYLGLOXIME METHOD.

No.	Description.	% Ni (Vol.).	% Ni (Grav.).	Difference.	C.cs. of Reagent used.
				%	C.CS.
21	Cr. Ni. steel	4.80	4.79	-.01	60.0
22	2½% Ni. steel	2.48	2.43	-.05	25.0
23	Cr. V. Ni. steel	2.00	2.04	+.04	25.0
24	Cr. Ni. steel	0.80	0.785	-.015	20.0
25	Cube nickel	99.30	98.91	-.41	80.0
26	Ni. Mn. steel	16.10	16.01	-.09	80.0
27	Cr. Ni. Mn. steel	15.36	15.23	-.13	80.0
28	Ni. Mn. Cr. steel	14.88	14.80	-.08	80.0
29	Ni. Cr. Mn. steel	15.36	14.95	-.41	80.0
30	Ni. Cr. Mn. steel	15.10	15.09	-.01	80.0

The Gravimetric Method.—The silicon previously removed, iron held up with tartaric acid, only one precipitation made, blank equivalent to .041% Ni on 1 gm., deducted in each case.

The Volumetric Method.—The iron was separated with bi-normal ammonia, in the presence of an excess of standard KCN, and the excess titrated with standard AgNO_3 after fractionating for the removal of the iron.

COMMERCIAL AND GENERAL NOTES.

Sterilised Salt.

Dr. Rappin and M. Grosseron, of the Pasteur Institute of Nantes, have recently carried on experiments with the object of determining the purity of rock salt and sea salt. These experiments have proved that sea salt, as now obtained, and even rock salt, contain numerous microbes. A bacteriological analysis of certain kinds of

salt showed that a considerable number of bacteria may be observed under certain circumstances. They belong to different species, and are of apophitic and pathogenic nature. There is no doubt that such impure salt is not suitable for preserving foodstuff, as it does not only make their preservation doubtful but is also apt to cause decomposition and injurious fermentation.

Thus, the object in salting certain substances in order to preserve them is completely defeated, and there is no cause for surprise that cheese makers, butter manufacturers and others are often disappointed with the poor keeping quality of their goods, as the microbes in the salt may easily develop under favourable conditions. It may also be assumed that many cases of illness which occurred after partaking of certain articles of preserved food must be traced to the action of the microbes introduced by the preserving salt.

It is, indeed, certain that the antiseptic quality of ordinary salt must be considered very limited, and that even if used in a saturated form it has not sufficient antiseptic power to completely destroy the bacteria if they find favourable conditions, under certain circumstances. Therefore, it is evident that the use of salt, as it is generally obtained by consumers, does not fulfil all requirements, and that it is necessary to render it more efficient by a suitable method which purifies it without altering its chemical composition, completely destroying all germs which occur on the surface and even within the crystals.

The Effect of Coal Tar Roads on Vegetation.

The allegation that the use of tar on roads has an injurious effect on the surrounding trees and vegetation for which the French botanist, Dr. Marcel Mirande, is held responsible, are pronounced unfounded by German experts. Herr H. F. Fischer, of Stuttgart, a well-known German specialist, has been investigating the subject, and he intends to lay the results of his experiments before the coming International Road Congress which will take place in London at the end of June of this year. Marcel Mirande based his allegations on the apparent harm done to trees in the Bois de Boulogne in Paris, but his charges against tar have been refuted by several French engineers. A prominent street in Bordeaux has been treated with tar for some years without the slightest damage to the trees bordering the street. Other towns, too, have practised tarring without injurious results, though one example is on record where the trees round a square were destroyed by tar. In this case (at Fontenoy de Comte) the tar was spread so close to the trees that it prevented the water from getting to the roots. It will be interesting to hear the conclusions which the German specialist draws from his investigations, which have been carried on with the usual thoroughness.

The Disinfecting Power of Soap.

That cleanliness is the beginning of antisepsis has been often repeated, and the disinfecting power of soap, which was for a time passed over in silence or even doubted, is now again brought to the front. Quite recently Dr. Pillod, of Paris, demonstrated that soap is naturally antiseptic. His researches were directed to its action upon the habitual agents of suppuration: staphylococci, streptococci and pyocyanic bacilli, and in his experiments he employed only white Marseilles soap.

In order to prove that white soap is naturally sterile, Dr. Pillod took fragments from soap which had been in

operating rooms and laboratories. These fragments he placed in a tube of bouillon, and submitted them for eight days to attempts at culture in closed vessels. The tubes were afterwards left for fifteen days in the atmosphere of the laboratory. Not one of eighteen samples gave any culture.

The fact is therefore established that soap is sterile in itself, and this property is easily explained by its chemical composition and the process of its manufacture. Soaps are real salts, oleates and palmitates, obtained by the saponification of fatty matters by powerful bases, soda being used for white soap. The manufacture of soap requires high temperatures (100°C . for five hours for solidification) and the action of concentrated lyes which are strongly antiseptic. Soap holds on an average 4.5% of free alkali, and contains no principle that is nutritive for bacteria.

An Opportunity for Chemists.

An inventive genius will probably soon have an opportunity of amassing a considerable fortune, if the proposal of a member of the Chilean Senate be adopted. According to the *Hamburger Nachrichten*, the Chilean Government is at present considering the question of delaying the threatened exhaustion of the nitrate deposits, the utilisation of which represents the chief industry of the republic and the main source of income for the state. Although the exhaustion is not quite so close at hand as some people are fond of prophesying, it will possibly take place within the next fifty years or so, if the present rate of nitrate production be continued.

If it were possible to utilise the impure layers of nitrate which, in addition to nitrate, contain a great amount of mineral salts and insoluble matter; and which for this reason have, so far, not been utilised commercially, the threatened exhaustion would be delayed indefinitely. Several attempts in this direction have been made without success. The above-mentioned proposal of the member of the Senate consists in offering a prize of £500,000 for an invention by which the so-called "Caliche" which remains after the nitrate is obtained, can be utilised. Half a million pounds sterling seems a large prize, but if one considers that the value of the annual nitrate production in Chile amounts to about £15,000,000 (without counting the by-products), it will be seen that the subject is of paramount importance to the Republic.

Interesting Development in the Continental Artificial Silk Industry.

For some years past (says the *Manchester Guardian*) the Vereinigte Kunstseide-Fabriken, Frankfort-on-Main, one of the largest continental producers of artificial silk by the gun-cotton process, has suffered seriously from the keen competition of the newer makers by the cupro-ammonium and viscose systems, and the handsome profits earned during the early years of the undertaking have given way to heavy losses, last year's balance-sheet disclosing a deficit of some 800,000 marks. Some time ago the directors decided to take up the viscose method, and began to manufacture by it, a procedure which resulted in a suit being brought against them by the Vereinigte Glanzstoff-Fabriken, Elberfeld, who claimed that the Frankfort firm were infringing their patents. Judgment was given against the defendants, who gave notice of appeal. In the meanwhile they worked out a modification of the original process, which they assert was in no way an infringement of the Elberfeld one. The product marketed appeared to be quite satisfactory, but the cost of manufacture is understood to have been much greater.

It is now officially announced that an understanding has been arrived at between the two firms. To clear off the heavy loss of the past few years the capital of the Frankfort company is being reduced from 3.65 million marks to 1.46 million marks and new shares to the amount of 1.54 million marks issued, thus bringing the capital up to three million marks. A large proportion of the new shares will be taken up by the Elberfeld concern, who will also be represented on the board by two directors. They also agree to grant a license to the Frankfort company, allowing them to manufacture according to their viscose patents, and also to give them the full benefit of their experience in working the process.

The Belgian Superphosphate Industry.

The Belgian manufacturers of superphosphate are at present bitterly complaining of the unsatisfactory state of the business. Instead of the rise in prices which they confidently expected, the tendency of the market is rather weaker. The unprofitable nature of the business is, however, partly the fault of the manufacturers, owing to their lack of unity. Contrary to the usual economic law, when raw materials get dearer every year and the demand for the manufactured article increases, too, the prices for superphosphates have not been raised correspondingly, and leave practically no profit. All the constituent elements of superphosphate, such as pyrites, phosphorites, coal—and of course the necessary packing—have risen in value. Phosphates alone are as much as 10% dearer than some time ago, and the cost of labour is constantly rising, yet, in spite of all this, the prices for superphosphate are tending downwards. It is suggested that this unsatisfactory state of affairs is entirely due to lack of unity among the producers, and the only remedy would therefore consist in an amalgamation of interests.

Aluminium Nitride.

During recent years considerable developments have taken place in methods for the industrial fixation of atmospheric nitrogen. One of these, introduced commercially by Serpek, consists in heating bauxite with carbon in an electric furnace at a temperature not exceeding $2,000^{\circ}\text{C}$. in an atmosphere of nitrogen. This treatment yields a product which consists chiefly of aluminium nitride (Al_2N_3).

It has been suggested that the impure aluminium nitride could be used directly as a manure, but as yet few experiments have been made with it, and the desirability of its use in this way remains to be established. The more profitable use of the nitride would seem to be its transformation into ammonium sulphate and alumina, and it is in this direction that the process is now being developed commercially.

Serpek has taken out a patent for effecting this transformation by treating aluminium nitride with a boiling solution of sodium aluminate of density 1.162—1.171; this results in the liberation of ammonia, which is absorbed by sulphuric acid, forming ammonium sulphate. The alumina liberated by the sodium aluminate passes into solution and is recovered in the hydrated form; the mother liquor which remains is of the correct strength for the treatment of further quantities of nitride. The impurities in this solution, chiefly ferrous compounds, form heavy residues which can be separated from the solution by decantation. A full account of the reactions involved in the above processes, together with estimated costs, will be found in *Le Moniteur Scientifique* (1911, 75, 861).

M. L.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.

28167/11. BADISCHE ANILIN AND SODA FABRIK, Ludwigs-hafen-on-Rhine. **Ammonia**. 14 December, 1911.

In the manufacture of ammonia by passing a mixture of hydrogen and nitrogen over a catalytic mixture of metals, metals which belong to different groups, or to different sub-groups, of the periodic system are employed. (3 claims.)

28605/11. F. BRÄUNLICH, Brünn. **Tin Tetrachloride**. 20 December, 1910.

Anhydrous tin tetrachloride is manufactured by subjecting tin dioxide at a high temperature to the successive, simultaneous or alternating action of acetylene and chlorine. (2 claims.)

28920/11. H. C. WOLTERECK and J. MOELLER, London. **Phosphates**. 22 December, 1911.

Phosphates are decomposed by subjecting them to the action of highly heated superheated steam at substantially atmospheric pressure. The phosphoric acid liberated is carried off by the steam. (1 claim.)

28929/11. G. A. CHAPMAN and S. TUCKER, London. **Ore Concentration**. 22 December, 1911.

Metalliferous ores are concentrated by agitating the ore with water containing a selective agent or mineral-frothing agent, and also a bisulphate of an alkali metal or a mixture of a normal sulphate of an alkali metal and sulphuric acid. The metalliferous matter is separated by flotation, and the liquor is treated with free acid to bring it back to its original condition for re-use. (2 claims.)

28974/11. F. RASCHIG, Ludwigshafen-on-Rhine. **Explosives**. 22 December, 1911.

According to the present invention, the combustible ingredients of an explosive consist of the simple sulphonates or disulphonates of the higher phenols. (3 claims.)

1177/12. DYNAMIT-ACTIEN-GESELLSCHAFT, VORMALS ALFRED NOBEL & Co., Hamburg. **Explosive**. 15 January, 1912.

An explosive of great blasting power is produced by adding aluminium silicide in suitable proportions to known explosives. (3 claims.)

3752/12. GENERAL ELECTRIC COMPANY, Schenectady. **Preventing Oxidation**. 14 February, 1912.

Metals are treated to protect them against the effects of oxidation or other similar corrosive agencies by heating the same in contact with aluminium powder. (2 claims.)

5659/12. C. A. MULLER and D. WOLF, Turn-Teplitz. **Cellulose Products**. 6 March, 1912.

The invention relates to a process for the manufacture of artificial silk, photographic films and like cellulose products, and in accordance therewith the liquid from which the silk or film is formed is a solution of bast sheath fibres obtained from hop runners. (3 claims.)

6118/12. B. D. SAKLATWALLA, Pittsburgh. **Vanadium**. 11 March, 1912.

Vanadium is recovered from material containing the same by dissolving out the soluble constituents and subjecting the solution to the action of an oxidising agent, comprising an oxy-acid compound of chlorine to precipitate the vanadium free from all other metals. (3 claims.)

7291/12. BADISCHE ANILIN AND SODA FABRIK, Ludwigs-hafen-on-Rhine. **Vat Dyes**. 25 March, 1912.

Vat colouring matters of the anthraquinone series are manufactured by subjecting an anthraquinone acridone, substituted with halogen in the benzene residue, to treatment with a nitrating agent and reducing the nitro-compound thus obtained. (3 claims.)

7669/12. E. JALOWEITZ, E. RICHTER and A. SCHÜCKHER, Vienna. **Brewing and Malting**. 1 April, 1911.

Water for brewing and malting purposes is improved by being heated under pressure and thereupon freed from precipitates by filtering or decanting. (1 claim.)

8512/12. BADISCHE ANILIN AND SODA FABRIK, Ludwigs-hafen-on-Rhine. **Tanning**. 10 April, 1912.

In tanning, there is employed as a tanning agent, a soluble aromatic compound, obtainable from formaldehyde (or a body giving rise to formaldehyde) and an aromatic phenol, or derivative thereof, which contains, besides a hydroxyl group, one, or more than one, acid salt-forming group. (2 claims.)

13591/12. FARBENFABRIKEN VORMALS FRIEDRICH BAYER & Co., Elberfeld. **Caoutchouc-like Substance**. 10 June, 1912.

The product obtained by Kondakow from beta-gamma dimethyl-erythrene (*Journal für praktische Chemie*, 64, 109—110) can be converted by heating, preferably under pressure, into an elastic caoutchouc-like product. (1 claim.)

15934/12. NORSK HYDRO-ELEKTRISK KVAELSTOFAKTIESELSKAB, Christiania. **Nitrate of Lime**. 8 July, 1912.

For effecting the solidification of liquefied nitrate of lime by means of cooled surfaces, the mass is spread in a thin layer on the cooled surface after it has been first highly cooled and been transferred into the form of a viscous mixture of solidified and non-solidified particles. (2 claims.)

16092/12. R. HÜBNER, Arlington. **Briquetting**. 9 July, 1912.

A briquette is formed by subjecting flue dust, clay, silica, lime and magnesia to the action of a solution of hydrofluoric acid, and subsequently to the action of pressure. (2 claims.)

16350/12. CHEMISCHE FABRIK VON HEYDEN AKTIEN-GESELLSCHAFT, Radebeul. **Stibinic Acid**. 2 August, 1911.

Phenylstibinic acid is manufactured by treating diazobenzene with antimonious acid or its salts. (5 claims.)

17594/12. E. O. LEGGETT, Niagara Falls. **Aluminium**. 29 July, 1912.

Aluminium is refined by fusion with an acid and a chlorate. (3 claims.)

23427/12. FARBWERKE VORMALS MEISTER LUCIUS AND BRUNING, Hoechst-a-Main. **Bluish-red Colour Lakes**. 15 March, 1912.

Bluish-red colour lakes are manufactured by precipitating by one of the methods used in the preparation of lakes, the dyestuff obtained by combining the tetrazo-compound of meta-tolidine with two molecular proportions of 2-naphthol-3:6-disulphonic acid. (2 claims.)



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INDUSTRIAL FELLOWSHIPS.

SOME time ago we dealt with the subject of Professor Kennedy Duncan's work at the Universities of Pittsburg and Kansas.

Further information to hand has an interest, and still further emphasises the different conditions which exist on the other side of the Atlantic.

In a recent address to the Franklin Institute, Professor Duncan claims that before his scheme came into operation, the American Universities were (and presumably are still) "turning out large numbers of men—chemical engineers, etc.—on a basis of a four years' course, but such men were merely *taught* men, they were not researchers, and under the conditions of contemporary factory practice were deprived of the possibilities of development, and were, in fact, for the purposes of research, merely ruined."

Professor Duncan states that the genuine men turned out by the Universities "young doctors of philosophy with a record of academic research and a capacity for creative work, were discouraged by the Universities of any ambition to enter applied research, and were led to consider the teaching profession as the only logical goal to their endeavours. He states that a man with brilliant research qualifications who entered applied science—among whom are the few contemporary first-class research technologists—did so under the views of academic disapproval.

"The reason for this lay in the fact that American science had through generations been built upon the basis of severe academicism and formalism. It was deemed contrary to University ideals and traditions, that research should have in view any utilitarian end; there was great insistence upon *pure* science, the implication being that applied science was *impure*, and constituted a degraded form of research."

Professor Duncan claims that he has modified the general position by emphasising the purely industrial side of his scheme, which has in the partnership established between student and manufacturers, which exists prominently, emphasised

certain factors which he has had in mind from the start in 1906.

Certain factors are said to govern the present economic conditions in industrial life in the U.S.A. They are stated to be the following :—

- (a) The existence of a high tariff which, whether good or ill for the people as a whole, certainly injured the efficiency of American manufacture by shutting out the competition of the efficiency of foreign manufacture.
- (b) The creation of combinations for the elimination of competition, and the consequent substitution of business intrigue for manufacturing efficiency.
- (c) The existence of large stores of raw materials everywhere available.
- (d) The needs of a rapidly-expanding population.
- (e) The evolution of an area of extravagance in purchasing.
- (f) An enormous development of the business of lying advertisement.

The advantages of this scheme are set out under the following headings :—

(a) *The University*.—That it more fully fulfils its function in increasing the sum of useful knowledge.

(b) *The Industrial Concern*.—Practice has already shown that results are obtained which were impossible under the old scheme. The college library, and important consultative facilities—mathematical, physical, engineering, bacteriological, etc., which are of such importance in such work, are freely offered to students working under this scheme. These advantages, laboratory, library, consultative, and inspirational, together with the supervision and administration of these Fellowships are offered by the University gratuitously to any company having important problems offering a reasonable chance of solution, under conditions which surround investigations with the necessary secrecy.

(c) *The Public*.—With the elimination of manufacturing waste, a fuller advantage taken of contemporary discovery, and the utilisation of natural raw material, general conditions will improve.

(d) *The Researcher*.—The conditions of working are claimed to be unique, and offer every opportunity of genuine achievement, and a full financial recognition of the same by way of a substantial material reward.

The Kansas University has built and equipped about a dozen laboratories under this scheme, while the Pittsburg University has provided a temporary building adequately equipped for the purpose.

A few examples of the investigations undertaken will suffice to indicate their nature.

VII. *Utilisation of Fruit Waste*.—\$1,000 a year for two years. Additional consideration of \$10,000.

IX. *Crude Petroleum*.—\$10,000 a year for two years. Collective interest of 10 %. (Six Fellows working on this problem.)

XI. *Cement*.—\$1,800 a year for two years. \$10,000 additional consideration.

Professor Duncan has recently extended the scheme in the direction of Multiple Fellowships which "employ the intensive services of men under the immediate direction of a Senior Fellow, who is responsible for his juniors to the Director," and that five of these have already been started.

The success of the scheme is claimed to be of a substantial nature, donations of many thousands of dollars' worth of apparatus in recognition of progress having come from the industrial world. The scheme has now been in active operation for five years and Professor Duncan "looks forward with confidence to the ultimate establishment of this system of Industrial Fellowships as a permanent relation between Industry and Learning." It is evident that under the special conditions which exist in America this scheme is receiving an extended trial and is being pushed through the mills of practical experience. Exactly what comes out the other side will be examined with a good deal of interest by those interested in the advance of technical investigation and research.

INSTITUTE OF CHEMISTRY.

THE 35th Annual General Meeting of the Institute of Chemistry was held at 30, Bloomsbury Square, on Monday, the 3rd March, Professor Raphael Meldola, D.Sc., F.R.S., President, in the Chair.

Professor Meldola, in the course of his Presidential address, remarked that the past year had been one of great activity, and that the Institute was to be congratulated upon the substantial progress made in several directions. The applications of chemistry in every field of human activity had been steadily increasing and the importance of professional chemists to the public welfare was becoming more and more recognised. They had not secured that full measure of public recognition to which they were entitled, but in this country all scientific affairs moved but slowly. The consolidation and the elevation of the profession and the maintenance of the status of the chemical practitioner would become more and more determined in the future by the standard of efficiency and of conduct set up by the Fellows and Associates. The most impor-

tant advance made in the year was the adoption by the Fellows and Associates, at an Extraordinary General Meeting convened for that purpose, of a scheme for securing a site and erecting a building for new headquarters for the Institute. This had been rendered possible by the raising of a fund which, although not complete, was considered sufficient to warrant the acquisition of the site. It had been originally estimated that about £15,000 would be required. Of this sum over £11,250 had been promised, £9,000 having been actually received. As far as could be gathered it was probable that a sum of at least £16,000 would be required, so that an endeavour had yet to be made to raise a further £5,000. The completion of the scheme cannot but be the most earnest wish of all who have at heart the reputation of this country, whose individual workers have contributed so nobly to the advancement of chemical science. It was hoped to create an establishment worthy of the dignity of the Institute as a professional body and of the service rendered to the community by its members. Continuing, the President referred to the recognition accorded to the qualifications of the Institute by Government departments at home, in the overseas Dominions, and in India. The Institute had taken its place as an imperial organisation, and it had set before it an ideal for which it was striving. It was hoped that in time every British chemist holding any position of responsibility, whether in the public service, in the teaching profession, in the chemical factory, or as a private practitioner, would be found on the register, and that the appearance of a name on that register should become a necessary public guarantee of efficiency in the same sense that a name on the medical register entitled a medical man to practise. While the status of the Institute was recognised as a collective body, it could not be said that the recognition of the members as individuals was satisfactory. This was equally true of the public analyst, the teacher and the chemical technologist. The question of remuneration was very much a matter of individuality and depended on three factors: the place where the work was done, the actual value of the work to the employer, and the professional status and personal character of the employee. These factors were so variable that it would be as impossible to standardise the value of every particular member as it would be to enforce a particular scale of remuneration for each individual member of any other professional body. It was thought that it might be possible to draw up a schedule of fees for the more routine work which would represent adequate remuneration, and a committee of the Institute was engaged in this task. If found practicable, the schedule when issued should, at any rate, serve as a useful guide to members in dealing with clients and public bodies. Until the whole level of public appreciation of the value of this profession was raised, the country was destined to lose the services of that highest type of cultured and trained chemist, of which other nations are more wisely availing themselves, to our detriment and their advantage. The Institute had sent representatives to give evidence concerning chemists in Government employment before the Royal Commission on the Civil Service. The best thanks of the Institute were due to Sir William Tilden and Sir William Ramsay for their services in this connection, and it was earnestly hoped that some practical amelioration of the existing state of affairs would result. One very important step in the desired direction would be made if the Commissioners could only see their way to adopt the recommendation that Government chemical departments should be controlled by chemists.

THE FUTURE OF MOTOR SPIRIT.

By PROFESSOR VIVIAN B. LEWES, F.I.C., F.C.S.

At the present moment there is no question of greater commercial and scientific interest than that of our future supply of petrol, and the means by which the increase of demand over production that is already making itself felt in increased price, can best be dealt with in order to avoid a serious check in what has become almost a necessity of modern life. In every country in the world the petrol-driven motor has increased in use with such rapidity that the demand for the lighter fractions of crude petroleum, of sufficient volatility to serve for use as a carburetting agent has led to a distillation and re-distillation of every oil supply capable of yielding it, and as the demand shows no sign of reduction in the rate of increase, it seems inevitable that the price must continue to rise until the demand is reduced either by reduction in the number of motors used, or by the introduction of other kinds of carburetting material.

Twenty years ago the lighter fractions from the distillation of the crude oil were a drug on the market, used only as a grease solvent, and to a very limited extent as an illuminant in sponge and Holliday lamps, but with the rapid rise of the motor car these fractions proved themselves to be the ideal fuel, and from an almost waste by-product they have risen to the position of being the refiner's most paying product.

The rate at which the demand has increased may be judged from the following figures, which show the imports of petrol into this country during the past eight years:—

Year.	Gallons.	Year.	Gallons.
1905 ..	18 millions	1909 ..	53 millions
1906 ..	25 "	1910 ..	55 "
1907 ..	34 "	1911 ..	70 "
1908 ..	40 "	1912 ..	80 "

so that in that period the demand has been more than quadrupled, whilst in America, France and several other countries, the increase has been even greater.

During this period, however, the world's production of crude oil has increased only from 28,500,000 tons in 1905 to 50,000,000 tons in 1912, so that the crude material has been less than doubled, and it is clear that as the most prolific new fields, such as the Californian, have yielded oil far poorer in the light fractions than the older sources, some radical alterations must be made if the English supply is to be kept at a usable price.

The chief sources of our supply during the past few years have been the American and Dutch East Indian fields, which, up to a point, competed vigorously for the English market, but the American spirit was only the surplus that could be spared after the home consumption had been satisfied, and as the demand in the States has increased, so the surplus available for export has diminished, until

in 1912 the sources from which we drew our supply were:—

Dutch East Indies ..	40 million gallons
America	16 " "
Holland	6 " "
Russia	5 " "
Roumania	4 " "
Other countries ..	9 " "

And the petrol from Holland came from the East Indian fields, so that more than half our supply came from fields which are owned by the Royal Dutch and Shell Companies.

The rise in price has been brought about by several factors, all tending in the same direction—the shortage of crude oil to meet the ever-increasing demand, insufficient transport facilities, and finally, the fact that the chief source of supply is in the hands of an extremely clever group of great financial strength, who are justified commercially in recouping themselves for the years during which competition with the American market kept prices low. That the excess of demand over supply is a far more important factor than most people admit is shown by the fact that the price of crude oil at the oil fields everywhere is touching record prices, whilst the insufficiency of the transport facilities will disappear probably with the fleets of oil tankers that are now under construction, and the opening of new pipe lines.

The one fact which stands out as perfectly clear is that with less and less petrol being exported from America owing to the increase in the home consumption, it is a certainty that unless some other source can be found to supply a large proportion of our needs, prices must rise, and every possible method of creating such a supply is being eagerly scanned and passed under review.

The only sources likely to yield a sufficiently large quantity at a sufficiently low price, are those portions of the petroleum outside the petrol fraction, products of the carbonisation of coal and shale, and products of fermentation.

Increase in the Yield of Petrol from the Crude Oil.—It is found that even with oils poor in petrol, such as the Californian crude oils, the gases given off during the escape of the oil from the well contain light hydrocarbon vapours which can be recovered from the gas by compression, and in the Oklahoma and Kansas fields about 12,500 gallons daily are recovered in this way, and yield a light spirit, which, on account of its great volatility, is valuable for mixing with heavier grade petroils. This process is still in its infancy and will undoubtedly spread to all the oil fields, and may increase largely the petrol supply by enabling a fraction of the kerosene distilling above 150° C. to be used in admixture with it.

Already the distillation of petrol is being carried further and further into the kerosene fraction, as is evidenced by the rise in specific gravity in commercial petrol. Fifteen years ago plenty of petrol of a specific gravity of '680 was obtainable, whilst now the bulk is '720 for car work, and often above '740 for omnibus and trolley motors. Care, however, has to be exercised in making such mixtures, as, if there is too much of the heavier fraction, there is trouble in starting the engine from cold, and it is apt to show a want of elasticity in heavy traffic, whilst with all such mixtures there is the risk of the portions left in the carburettor becoming what is termed "stale," owing to the more rapid evaporation of the more volatile portions.

Another process being largely experimented with is the distillation of the heavier fractions of petroleum in contact with catalytic agents, such as nickel, in various conditions.

One of the most promising lines, however, for increasing the yield of petrol from heavy distillates is to be found in the so-called "cracking" of the residues in order to simplify their structure into hydrocarbons of lower gravity. The idea of distilling oil under pressure was first patented by James Young in 1865, and he found that by treating shale oil in this way the percentage of light oil was notably increased. In 1871 Thorpe and Young distilled paraffin wax under a pressure of 25 lbs., obtaining in the distillate light hydrocarbons akin to petrol in gravity, and they also demonstrated and proved, that on subjecting a heavy hydrocarbon to heat and pressure there is produced a mixture of saturated and unsaturated hydrocarbons of lower boiling point and greater volatility than the original oil. The same results were obtained by Benton in 1887 under high pressures, whilst in 1889 Sir James Dewar and Sir Boverton Redwood patented the distillation of heavy grade oils and condensing the products under pressure, whereby lighter oils and spirit were produced. At the oil fields themselves a method of prolonging the period of heating, resulting in an increased yield of the lighter fraction, has been practised for some time, the tops of the stills being left without any non-conducting coating, so that a portion of the distilling oil condenses there and drips back into the retort, where it undergoes a further period of heating.

A process which is being worked successfully at the present time for the production of light fractions from a heavier grade of oil employs for the purpose what is known as "solar oil," which is obtained from American oil after the lighting portion has been distilled off. The "solar oil" is sprayed with water into long iron retorts packed with iron turnings and kept at a temperature of 600° C. As the water vapour and oil pass through the retorts the oil is cracked, and the vapours travel forward to an atmospheric condenser; in this the undecomposed and heavier oil vapours condense and are returned to the retorts to be again heated, whilst the lighter portions passing on are condensed in water coolers, and the lightest spirit passing on as vapour in the

gas is subjected to scrubbing by oil; the permanent gases left after this treatment going to a holder, and being afterwards used for heating the retorts. The condensed and scrubbed out products are then heated in a continuous steam still and the spirit distilled off, the residual oil from the still and first condenser being mixed with fresh solar oil and passed through the retort again.

Most promising results are being obtained by this method, 39 gallons of petrol resulting from 100 gallons of solar oil, whilst of the remaining products 13 gallons are solvent spirit and 13 gallons an excellent varnish.

The analysis of both petrol and the gas obtained in this process shows that the changes which give rise to their formation are of the character first indicated by Thorpe and Young, and that heavy, saturated molecules are splitting up into simpler saturated and unsaturated hydrocarbons, whilst it is of special interest to note that the unsaturated hydrocarbons are chiefly naphthenes, which suggests that the variations found in the character of crude oils are more likely due to different conditions of formation rather than to differences in origin.

It is clear that processes which rely for their commercial success upon the use of heavier fractions from the crude oil can successfully compete in the petrol market only whilst the raw material is sufficiently cheap to enable the manufacturing processes to be carried on at a profit, and the rise in price of the crude oil in the fields and the general rise in price of all petroleum products suggest that a gradual rise all round will continue, but this by no means follows, as the rise in the price of crude oil in the fields is due largely to the demand for oil to distil for petrol, whilst the rise in price of the other residuals in this country is due largely to shortage in shipping facilities and high freights, so that only the most paying product, *i.e.*, petrol, has been chosen for shipment, and large stores of heavier fractions are being held back until the fleets of oil ships now under construction are completed, when, with fall in freights, a probable drop in price of heavier oil may be expected. Any source of motor spirit, however, that is dependent on the supply of crude oil can last only for a limited period, and one's attention therefore turns naturally to coal as a source from which volatile liquid hydrocarbons may be obtainable to eke out the supply.

When a good bituminous coal is subjected to destructive distillation the products formed vary with the temperature and conditions employed, which govern the secondary reactions taking place in the products of the primary decomposition, so that from a ton of such coal one can obtain 13,000 cub. ft. of 14-candle power gas and 9 gallons of poor tar, whilst under other conditions one can get 3,500 cub. ft. of rich gas and 30 gallons of tar, in each case the physical and chemical characteristics of the coke residue also showing a considerable difference.

These represent the two extremes possible, and it is found that as the tar increases in volume, owing to the conditions of distillation, so its specific

gravity falls, and it becomes more oily or "paraffinoid" in character, whilst aromatic hydrocarbons are replaced by paraffins and naphthenes. In the ordinary methods of coal gas manufacture, where gas yield is taken as the criterion of success, the secondary changes and decompositions have gone so far that the tar contains only a trace of the more volatile portions, and the benzol vapour is left in the gas as far as possible to keep up its heating and lighting power.

The result of this is that the fraction of tar consisting of benzol, toluol and small quantities of xylol is very low, and as only a very few of the large works treat the tar themselves, and the largest proportion is used for road-making, the total quantity available from this source is only some 50,000 gallons per annum of a quality that could be used as a motor spirit, although some 15 million tons of coal are used annually in the production of gas.

The coke-oven recovery plant presents a much more promising source of benzol, as not only is the initial yield larger, owing to the slow heating of a large mass of coal, but the benzol vapour is scrubbed out of the gas. In England only some 42% of the 17 million tons of coal converted annually into metallurgical coke is treated in recovery plant, only 81 out of a total of 224 coking works using such plant, and the total quantity of benzol recovered is about 8,000,000 gallons, probably over a third of this being exported.

At the present time the demand for a smokeless fuel of more easy ignition than coke and capable of burning with a flame, as well as the demand for motor spirit, have given rise to several processes in which further modifications in carbonisation are being attempted, and which yield much larger volumes of liquid products, the lighter fractions of which are more akin to petrol than to benzol, and when these assume manufacturing proportions, they will help, undoubtedly, to supply the ever-increasing demand.

Commercial benzol contains about 140 grs. of sulphur per gallon, and has to undergo a process of purification from this before it is fitted for motor use, as otherwise it gives a more than usually foul-smelling exhaust, but in running it is 12% more powerful than petrol, and as regards elasticity and starting is quite as good.

The Scotch shale oil industry, concentrated as it is upon the narrow strip of strata only some 6 miles in width that stretches away from near Dalmeny on the Firth of Forth to the moorlands around Tarbrax and Cobbinshaw, also can subscribe its quota to the supply of motor spirit, and under the normal conditions of working, yields about 600,000 gallons of spirit per annum, but large as this quantity sounds, it is only 0.75% of the 80 million gallons consumed last year. It must be remembered, however, that the new naval base at Rosyth is close to the shale fields, and every effort will probably be made to increase the amount of fuel oil available for the navy, and as any increase in this means also increase in the lighter fractions,

it is quite possible a larger quantity of motor spirit will be available.

The world's stores of petroleum, coal and shale are all being rapidly depleted, and in the not very distant future it will be to alcohol that we shall have to turn, and it will then be found that alcohol, denatured with 10% of benzol, and tinged by a trace of anilin dye, will give a motor spirit at once safer, more pleasant in use, and sweeter in exhaust than the petrol of to-day, and that although the calorific value of such a mixture is only 0.6 of the value of petrol, the smaller amount of air needed for its combustion, the increased explosive range of the mixture and the higher compression that could be used in the cylinder, all combine to make it the ideal motor spirit, and one about which no doubts can be raised as to the possibility of future supply.

Year's Rubber Exports from the F.M.S.—According to information given by the Federated Malay States Government to the Malay States Information Agency, the exports of plantation rubber from the Federated Malay States for the month of December amounted to 3,693,929 lb., making a total for the year of 34,718,015 lb. Appended are the comparative statistics for 1910 and 1911:—

	1910. lb.	1911. lb.	1912. lb.
January	768,743	1,329,170	2,730,576
February	728,458	1,490,849	2,715,767
March	899,383	1,916,219	3,089,583
April	1,123,097	1,235,917	2,285,390
May	877,435	1,147,488	2,255,034
June	879,675	1,229,754	2,305,915
July	971,469	1,581,993	2,695,861
August	981,022	1,651,845	3,655,535
September	1,110,476	1,677,062	2,968,121
October	1,484,847	2,182,857	3,210,831
November	1,153,137	2,104,317	3,111,473
December	1,234,669	2,147,859	3,693,929
Total	12,212,411	19,695,330	34,718,015

These statistics refer to the Federated Malay States only, and do not include rubber exports from the Straits Settlements or the Non-Federated Native States. The output for 1912 constitutes a new record for the Federated Malay States. In 1906, the total export of plantation rubber from the Straits Settlements and F.M.S. ports amounted to 1,035,601 lb., valued at £399,000. In 1909, the export had risen to 6,112,023 lb., valued at £2,340,000, and in 1911 the total export of 19,695,330 lb. represented a value of nearly £6,000,000.—*Chamber of Commerce Journal.*

Procter International Research Laboratory Fund.—The following further contributions have been received towards this fund:—£105 from Messrs. Turney Bros., Trent Bridge Works, Nottingham; £100 from Messrs. E. & J. Richardson, Newcastle-on-Tyne; £105 from the Association of the Leather Trade of Leeds and District; £50 from London & District Tanners' Federation; £50 from Messrs. Röhm & Haas, Darmstadt, Germany; £25 5s. and an annual subscription of £5 5s. from the Manchester, Liverpool and District Tanners' Federation; £25 from the Pro-Chancellor of Leeds University.

THE CINNAMIC ACID PROBLEM.

By E. JOBLING, B.Sc., A.R.C.Sc.

THE cinnamic acids have long provided the most notable exception to our modern hypotheses regarding the stereoisomerism of chemical compounds. In other surveyed parts of this vast field, every addition to our stock of experimental data has furnished another triumphant vindication of the accuracy of the theories involved—with this important exception, and here, further research only served to deepen the mystery which surrounded it. Seeing that the van't Hoff-Wislicenus conception admits of only two stereoisomers, it was, to say the least of it, decidedly puzzling to find that no less than *eight* so-called isomeric cinnamic acids were described in the pages of chemical literature. To reconcile experiment with theory might well seem a hopeless—almost an impossible—task, yet this is the brilliant achievement which we are now able to record.

During an investigation upon the decomposition products of the alkaloids occurring with cocaine, Liebermann, in 1890, obtained an acid, called by him isocinnamic acid (m.p. 58°), identical in all chemical respects with the ordinary well-known cinnamic acid (m.p. 133°), yet differing from it in its greater solubility and lower melting-point.* The alkaloids were decomposed with hydrochloric acid, and the filtrate extracted with ether, when a semi-solid mass remained after evaporation from which, by a long process of separation, the isocinnamic acid was isolated. Singularly enough, before the year was out, a further acid was brought to light by the same investigator. In his experiments upon the previous isocinnamic acid, Liebermann had noted that the melting-point of the acid, if taken immediately after preparation, was somewhat lower than that which it assumed on standing, and he was therefore led to re-examine the crude semi-solid mixture afore-mentioned. In this way he discovered the third isomer, which he labelled allocinnamic acid, (m.p. 68°). In 1895, still another acid, also called isocinnamic acid (m.p. 42°) was added to the list by Erlenmeyer, senr., who reduced, by the aid of Zn dust, each of the two known bromocinnamic acids, Glaser's α and β modifications, obtaining ordinary cinnamic acid from the α acid, whereas from the β acid the new cinnamic acid resulted. By 1895, therefore, the existence of four supposedly-isomeric cinnamic acids, differing only in crystalline form, solubility and melting-point, was fairly definitely established.

Naturally, these observations were not permitted to pass unchallenged, particularly those relating to the existence of the two iso-acids, now known to be the most labile and, consequently, the most difficult to obtain. Indeed, in 1903, both Liebermann and Michael declared against the existence of the acid of Erlenmeyer, senr. Accumulating evidence, however, has placed the individuality of all four acids entirely out of question.

The same cannot be said of the remaining acids, which we owe to the activities of Erlenmeyer, junr. This investigator has attempted to resolve both ordinary and allocinnamic acids, and claims to have obtained from each two components of enantiomorphously-related configuration. In the case of ordinary cinnamic acid from storax, fractional crystallisation of the brucine salt yielded two acids, α and β storax-cinnamic acids. Cinnamic acid prepared synthetically by Perkin's method, Erlenmeyer, junr., showed later to be a mixture of storax-cinnamic acid and another acid, hetero-cinnamic acid, which was itself resolved into two components, α and β hetero-cinnamic acids. To these, still another cinnamic acid by the same investigator must be added. Criticism by Marckwald, Rüber and others has demonstrated, however, that the subtle differences which led Erlenmeyer, junr., to his startling conclusions rest on no experimental basis, and it is now accepted by all but Erlenmeyer, junr. himself, that his acids belong to the class of chemical phantoms.

At the beginning of 1909, then, four cinnamic acids were definitely known, and chemists were beginning to despair of solving the chemical conundrum. But in this year appeared a paper by Biilmann, which at once afforded a simple, though at the same time a complete, explanation of the whole difficulty. In a masterly research, Biilmann showed that the three acids other than the ordinary cinnamic acid were not isomeric, but separate forms of the same trimorphous acid. In other words, each of the three polymorphous acids differed only in the manner in which their molecules as a whole were crystallographically arranged, and not in the spatial arrangement of their atoms, as obtained with their monomorphous isomer, ordinary cinnamic acid. The identity of the three acids was demonstrated by melting any one of them, and then inoculating the cooled melt with a crystal of the acid desired, when the whole mass solidified to that acid. Precautions were observed, especially in the case of the most labile acid, to avoid aerial inoculation with either of the other acids, and very careful sterilisation was found to be essential to the success of the method.

Biilmann's results were immediately confirmed by independent observations of Liebermann; as also by the work of Stobbe, who obtained identical absorption spectra for each of the three acids. More recent work adds still further corroboration. Thus Biilmann obtains practically the same electrolytic dissociation constant for the three acids, while Stobbe has proved the optical identity of the three melted acids by refractometric measurements. Stobbe also undertook, in 1911, a very careful repetition of Biilmann's experiments, and, besides fully confirming the latter's results, shows that the

68°-acid is the stable, the 58°-acid the metastable, and the 42°-acid the labile polymorph.

Having thus settled the difficulty as to the number of isomers of cinnamic acid, Biilmann next attacked the question of the relative configurations of ordinary cinnamic acid and its trimorphous isomeride. Hitherto, ordinary cinnamic acid had been given the fumaroid formula, a supposition which was considerably strengthened by an observation of Paal and Hartmann in 1909, who demonstrated its ready formation from phenyl-propionic acid by reduction with colloidal palladium. Biilmann was able to give further evidence as to the likelihood of this view by obtaining a complex mercury compound from ordinary cinnamic acid, but not from allocinnamic acid, a formation which takes place only in the case of the fumaroid variety of a stereoisomeric acid. This evidence, however, corroborative as it is, does not effectually close the question.

It was left to Stoermer, towards the end of 1912, to bring forward conclusive evidence as to the correctness of the above view. In previous researches this investigator had shown that, when exposed to the ultraviolet rays of a mercury lamp, unsaturated acids, and, indeed, other stereoisomeric compounds, are transformable into their labile modifications, and it was by an application of this method that he succeeded in solving the problem of the configuration of the isomeric cinnamic acids. He found that

the ordinary *o*-nitrocinnamic acid could be transformed by a ten days' exposure in pyridine solution to ultraviolet rays into a labile isomer, allo-*o*-nitrocinnamic acid. On reducing both to the corresponding amino-acid, the allo-*o*-aminocinnamic acid was found to be immediately converted into carbostyryl when carbon dioxide was passed into an aqueous solution of its barium salt, whereas the ordinary *o*-amino-cinnamic acid can only be transformed into carbostyryl by indirect methods. Allo-*o*-amino and cinnamic acid, being directly capable of ring formation, must therefore possess a *cis* configuration. By diazotisation and reduction, the ordinary *o*-aminocinnamic acid yielded common cinnamic acid, whereas the allo-*o*-amino acid gave allocinnamic acid; from which it follows that ordinary cinnamic acid must be represented by the *trans* configuration and allocinnamic acid by the *cis* formula. Additional evidence of a similar nature was adduced by Stoermer, but the demonstration already mentioned will be seen to be sufficient to settle once for all the question of the constitution of the cinnamic acids.

The results of these epoch-making researches may be summarised in the statement that of the two theoretically-possible cinnamic acids, the *trans* form is the ordinary cinnamic acid (m.p. 133°), while the *cis* form exists in three isomorphous modifications, melting at 42°, 58° and 68° respectively.

THE CONSTITUTION OF CHLOROPHYLL.

By ARTHUR CLAYTON, D.Sc. (Lond.), A.R.C.S.

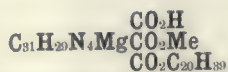
MORE than eighty years have passed since Wöhler obtained the first artificially prepared organic compound by the conversion of ammonium cyanate into urea, and since that time chemists have laboured incessantly at the study of organic substances. The enormous strides which have been made in our knowledge of the carbon compounds bear witness to the astounding success with which these investigations have been attended, yet the field is so vast that the chemical nature of many of the most widely occurring substances is still wrapped in almost impenetrable mystery; thus very little is known of the constitution of such compounds as starch, cellulose, albumin, etc., although these substances may be said to lie at the very foundations of the organic kingdom.

Under these circumstances it is especially gratifying to note the recent development which has taken place in our knowledge of the constitution of chlorophyll, which, as is well known, forms the green colouring matter of plants, and has functions of such fundamental importance in the vegetable world.

The study of chlorophyll has attracted the attention of chemists for many years, but until quite recently the chemistry of the substance consisted of a number of apparently disconnected facts which threw but little light on the constitution of the compound.

The difficulty of the investigation arises chiefly from the high degree of complexity possessed by the molecule, which is represented by the formula $C_{55}H_{72}O_6N_4Mg$. Notwithstanding the forbidding aspect of this formula, the labours of Willstätter and others have now reduced the chemistry of chlorophyll to comparative order, and considerable insight has been obtained into the constitution of the molecule.

It has been found that when extracted under carefully regulated conditions chlorophyll is obtained in an amorphous state, the "crystalline chlorophyll" obtained by other methods being formed as a result of decomposition. This fact was recently ascertained by Willstätter, who has also made the important discovery that amorphous chlorophyll is hydrolysed by cold dilute potassium hydroxide, with the removal of methyl alcohol and phytol ($C_{20}H_{39}OH$) and the formation of the potassium salt of a tribasic acid, which has been termed chlorophyllin. Hence it may be considered to be proved that chlorophyll is simply the di-ester of chlorophyllin, in which two of the carboxyl groups are esterified by methyl alcohol and phytol respectively, as shown by the subjoined formulæ (1 and 2).



1. Amorphous Chlorophyll.



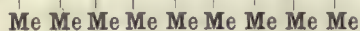
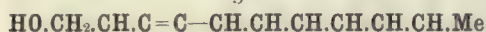
2. Chlorophyllin.

From this point therefore, the study of the constitution of chlorophyll resolves itself into an investigation of the constitutions of phytol and the nitrogenous complex.

Phytol, $C_{20}H_{39}OH$, is known to be an unsaturated alcohol which, when treated with oxidising agents yields phytenic acid, $C_{19}H_{37}CO_2H$, and a ketone of the formula $C_{15}H_{30}O$. The formation of phytenic acid (an acid which contains the same number of carbon atoms as phytol), proves that phytol is a primary alcohol. Further, since there are twenty carbon atoms in phytol, the formula of the above-mentioned ketone shows that the ethylenic linkage is situated between the fifth and sixth carbon atoms, for it is a well-known fact that unsaturated compounds spilt at the point of unsaturation when treated with oxidising agents. Finally, since phytenic acid readily yields a stable lactone, the ethylenic linkage must be in the $\beta\gamma$ -position with regard to the terminal carbon atom. These facts prove that the first five carbon atoms must be present in one of three possible arrangements, of which that shown in formula 3 is considered to be much the most likely. With regard to the constitution of the $C_{15}H_{20}$ residue, absolute proof has not yet been obtained, but the action of ozone and other oxidising agents points strongly to the structure indicated in formula 4.



3.

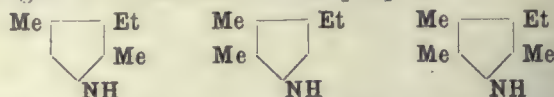


4. Phytol.

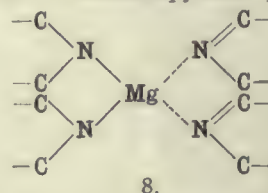
It is interesting to note that the peculiar structure assigned to phytol has given rise to the suggestion that it may be formed in plants by the condensation of some such hydrocarbon as isoprene, and although no direct evidence has been adduced in support of this hypothesis, the idea is attractive because it suggests a genetic relationship between phytol and such groups of compounds as the caoutchoucs and the terpenes.

Turning now to a study of the nitrogenous complex present in chlorophyll, a problem of greater difficulty, and probably one of greater importance is presented, and it may as well at once be confessed that very little is known of the constitution of this portion of the molecule. It has recently been shown, however, that the reduction of chlorophyll by different methods yields a mixture of three pyrrole derivatives; hæmopyrrole, isohæmopyrrole, and phyllopyrrole (formulae 5, 6, and 7 respectively); hence it may be deduced with a fair degree of certainty that the nitrogenous complex is based on a pyrrollic structure. Not unconnected with this conclusion is the suggestion recently made by Willstätter as to the state of union of the metallic atom. This suggestion involves the use of subsidiary valencies, the magnesium being supposed to be held in the manner indicated in formula 8. The idea is the outcome of the studies of Werner, Ley, and Tscugaëff on the metallic derivatives of imides, biuret, and dicyanodiamidine, and is also supported

by the fact that since the carboxyl groups of chlorophyll are not instrumental in holding the magnesium atom, only the groups containing nitrogen are available for this purpose.



5. Hæmopyrrole. 6. Isohæmopyrrole. 7. Phyllopyrrole.



8.

Apart from the above-mentioned changes caused by reduction, the investigation of chlorophyll has been prosecuted by an inquiry into the action of hydrolytic agents on the nitrogenous complex. It has been found that acid hydrolysis leads to the elimination of the magnesium, whilst hydrolysis with alkali hydroxides leaves this metal intact and effects other changes in the nitrogenous complex. By alternate acid and alkali hydrolysis, a complicated series of products has been obtained which, in all probability, will ultimately be of vital importance in assigning a constitutional formula to chlorophyll.

These investigations have led to two important results. In the first place it has been rendered highly probable that in amorphous chlorophyll, where two of the carboxyl groups are esterified by methyl alcohol and phytol, the third acid group is present in the lactam arrangement $.CO.NH.$ or the hydrated form thereof. Secondly, direct proof has been obtained of the fact that chlorophyll as it occurs in nature is not homogeneous, but consists of two components, which possess the same general structure in different states of oxidation. This composite nature of chlorophyll has been suspected for some time, and its recognition is of importance because it offers the significant suggestion that in the processes of assimilation, the pigment may exercise chemical functions in addition to playing the physical part usually ascribed to it.

The foregoing survey of our present knowledge of the constitution of chlorophyll indicates the paths along which the study of this important pigment is being prosecuted. The whole question is necessarily of the most complicated nature, but is illustrative of the problems which confront the chemist who ventures to inquire into the nature of the constituents of the organic world. Every day brings chemistry into closer contact with biological science, and great possibilities may arise from their ultimate and inevitable union. It is not impossible that the study of the functions of highly complex molecules will bring to light phenomena of unprecedented nature. Research in natural science during only a few decades has resulted in the discovery of wonders undreamt of a century ago, and it would need wisdom greater than that of man to set a limit to those secrets of nature which yet remain to be revealed.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

ENZYMES.

By E. FRANKLAND ARMSTRONG, D.Sc., Ph.D., F.C.G.I.

If we define enzymes with Bayliss as catalytic agents produced by living organisms, their comparison with other catalysts is a matter of course. The behaviour of acids as catalysts in promoting hydrolysis has been the subject of exhaustive study; emphasis has been laid repeatedly on the many points of similarity as well as difference in the behaviour of acids and enzymes towards the same substance. These considerations are quite apart from the essentially selective action of enzymes, which differentiates them entirely from all other hydrolytic agents, and indeed must form part of their definition. In this respect, that given by Bayliss is incorrect, and it is preferable to define enzymes as selective colloidal catalysts, present in living cells, and destroyed by heat. Enzymes being colloids must have a great development of surface as compared with crystalloid acids; this is another point of difference.

A well established fact in connection with enzyme action is that when the proportion by weight of enzyme is very small (and consequently the molecular proportion is still smaller) compared with that of the substance on which it is acting, equal amounts of the hydrolyte are changed in successive equal intervals of time; that is, change proceeds at a linear rate. It seemed feasible to suppose that were the proportion of acid to hydrolyte similarly reduced, always bearing in mind the smaller molecular weight of the acid as compared with that of the enzyme, the change in the case of acids also would become linear instead of logarithmic.

Experiments made in 1904 by E. F. Armstrong and R. J. Caldwell, in which all the precautions then available to secure experimental accuracy were taken, appeared to confirm this hypothesis. The hydrolysis of cane sugar in highly concentrated solutions, when effected by sufficiently dilute acid, appeared to take place during its earlier stages at a linear rate.

The importance of this conclusion made its verification at a later date desirable, when very much more delicate apparatus was available for maintaining a constant temperature and measuring the amount of change. This has been undertaken by Mr. F. P. Worley (*Proc. Roy. Soc.*, 1912, A 87, 555), who, in addition to his own experiments, has recalculated the values obtained by Armstrong and

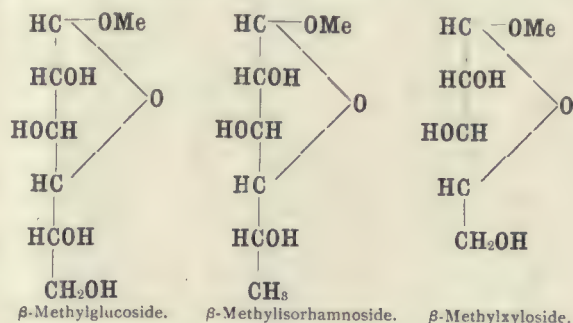
Caldwell, using the equation, $K = \frac{1}{t_2 - t_1} \log \frac{a - x_1}{a - x_2}$, which he has shown to give more trustworthy values for the velocity constant K than are given by the simple logarithmic expression $K = \frac{1}{t} \log \frac{a}{a - x}$, usually adopted and used by Armstrong and Caldwell.

Mr. Worley, however, finds no evidence that change caused by a small proportion of acid proceeds at a linear rate initially. The indications of such, obtained previously, are attributed to the temperature at the commencement of the experiment not having reached a steady value. The

consequent error in the initial value a affects all the calculated values of K , but to an unequal extent. It is proved, therefore, that acids and enzymes differ in respect of the linear portion of the hydrolysis curve.

The classic researches of Emil Fischer, concerning the action of emulsin and maltase on the alkyl saccharides¹ of a number of carbohydrates, have demonstrated beyond doubt the relationship of the enzyme to the configuration of the hydrolyte. Action depends on the enzyme finding a molecular arrangement, correct as to the arrangement of the groups on each individual one of its asymmetric carbon atoms, before it can effect hydrolysis of the methoxyl group attached to the terminal member of the chain.

The striking difference in the behaviour towards emulsin of β -methylglucoside and β -methylxyloside which, as the following formulæ show, are so closely alike, was particularly emphasised by Fischer.



He has now prepared an alkyl methyl pentoside—namely β -methyl-d-isorhamnoside, which, as the formulæ show, is intermediate in structure between the glucoside and xyloside. In the new saccharide the CH_2OH group of glucose is replaced by CH_3 —the change in configuration is not enough, however, to put the compound out of harmony with emulsin. The change in passing to the xyloside is more profound since, in replacing methyl by hydrogen, one of the four asymmetric carbon atoms loses its asymmetric character. In consequence its position relative to the rest of the molecule is no longer fixed, and this part of the compound becomes out of harmony with the enzyme, which is no longer able to effect hydrolysis.

Fischer's new discovery is a welcome reminder of the essentially specific nature of enzyme action, which to judge from some recent speculations, was not unnecessary.

Advance in any particular branch of chemistry usually coincides with the introduction of a new and exact method of measuring change, and Sørensen's so-called formol titration of amino acids forms no exception to this statement. Amino acids *per se* cannot be titrated with alkali, but in presence of formaldehyde it becomes possible to titrate the carboxyl group. Henriques and Sørensen

¹ We use alkyl saccharides as a generic term for the alkyl glucosidic derivatives of the sugars, so as to avoid the confusion introduced by using the term alkyl glucoside in a general sense as well as in a specific sense.

propose to carry out the titration in successive stages. The liquid tested, which is neutral to litmus paper, has a little phenol phthalein added, followed by N/5 sodium hydroxide until it is just red (1) and more till it is deep red (2) to match a control containing a drop of phenolphthalein and a known amount of alkali. Neutral formaldehyde is then added, and the titration continued until again a rose-red (3) and a deep-red (4) colour are obtained. After correcting for the control solution, the ratio of the alkali added at stage (4) to stage (1) is calculated. For the monoamino acids, glycine, alanine, etc., this is as high as fifty; for dipeptides, such as glycylglycine, it is only two.

The titration ratio thus affords a means of discriminating between the formation of polypeptides and amino acids during the decomposition of proteins. The method has been applied by Henriques and Gjaldback (*Zeitsch-physiol. Chem.*, 1911, 75, 363) to the study of peptic and tryptic digestion with interesting results.

In animals the proteoclastic enzymes are of two kinds, viz., the peptic enzyme of the stomach, which acts in an acid medium, and the tryptic enzyme of the pancreas and other organs which acts preferably in alkaline media.

Experimenting with a number of different proteins it is found that tryptic digestion proceeds farther than peptic digestion, as regards the proportion of the total nitrogen rendered titratable by the formaldehyde method. In the case of peptic digestion, the titration ratio is small and does not change as hydrolysis proceeds. With trypsin, the ratio is larger almost from the first and increases throughout hydrolysis. In other words, the action of pepsin is almost entirely to produce peptones and polypeptides, whereas trypsin eliminates amino acids from the commencement of the change. These conclusions agree with the facts found by purely chemical examination of the products formed.

The action of pepsin on the products of a trypsin hydrolysis causes about 5 to 7% further change but the titration ratio becomes smaller. It would appear that trypsin splits off amino acids from the protein molecule, leaving a relatively large complex unattached. This, in its turn, is broken down by pepsin into polypeptides. A tryptic following a peptic digestion is the most effective manner of degrading a protein, but the titration ratio is less than with trypsin alone.

The course of the hydrolysis of protein by hydrochloric acid alone shows great similarity with that by pepsin, and it is suggested that pepsin is to be regarded as a catalyst magnifying the activity of the acid. Alkaline and tryptic digestions are also as a whole very similar, the differences which do exist being most probably due to the secondary changes induced by the alkali.

Work on these lines appears very suggestive, and it is likely to advance the knowledge of the inner structure of the proteins, a problem which is beginning to be attacked with success in several different ways.

THE EXTRACTION OF POTASSIUM SALTS FROM SILICATE ROCKS.

By WALTER C. HANCOCK, B.A. (Cantab), F.I.C.

FROM the results of a large number of rock analyses, F. W. Clarke and others have computed the average percentage composition of the earth's crust, and estimate that potassium amounts to 2.35% of the total, which is equivalent to 2.83%, calculated as oxide. Although this appears at first sight a comparatively small amount, our idea of its

order of magnitude is certainly modified by the fact that iron and aluminium are the only metals, extensively employed in the arts, that find any mention in the estimates; such widely used metals as lead, copper and zinc, with an annual production of nearly 3,000,000 tons, are grouped together with about sixty other elements into a single class, under the heading of "Other Elements," which only amounts to about 0.07% of the total crust. It must, of course, be borne in mind that, although in these estimates iron accounts for about 4 to 5% of the earth's crust, much of this is present in forms that are unsuitable for the commercial production of the metal, and, in the case of potassium, only a relatively small amount of the total known to exist is at all easily obtainable.

Hitherto the chief sources of potassium salts have been the saltpetre deposits found in many tropical countries, the ashes obtained from the incineration of forest trees in North America, Norway, Sweden, and elsewhere—a supply that obviously decreases as forest lands are depleted and not replanted—the ash of marine plants used for the manufacture of iodine from "kelp," the residues obtained in the manufacture of beet sugar, and, lastly, the salt deposits of Stassfurt, which consist of carnallite, a double salt of potash and magnesia. In addition to these well-known sources of supply, the large percentage of potassium in the older crystalline rocks has long been recognised as a possible source if it could be economically extracted, and the wide geographical distribution of those rocks presents the further advantage of breaking down the monopoly of any specially localised supply. Indirectly, through the instrumentality of natural agencies, some at least of this potash has been recovered; by the weathering of felspathic soils the potash has been rendered water-soluble and absorbable by plants and trees, and, on the incineration of these, has been left in the "pot-ashes." The chief potash-bearing minerals of the older crystalline rocks are the feldspars and micas, but, apart from these rocks, deposits of the mineral feldspar, are available, which have the obvious advantage that the proportion of potassium in them is higher, since they do not contain quartz and other minerals. The chemical formula of orthoclase, the chief potash-bearing feldspar, is $K_2O \cdot Al_2O_3 \cdot 6SiO_2$, which corresponds with the percentage composition:—

K ₂ O	..	..	..	..	16.9
Al ₂ O ₃	..	..	..	..	18.4
SiO ₂	..	..	..	..	64.7
					100.0

Owing to the presence of impurities, however, samples of commercial feldspar, as a rule, do not contain more than about 12% of potassium oxide.

It would be impossible here to enumerate all the processes that have been suggested for the extraction of water-soluble potassium salts, the form in which these salts are required for agricultural purposes, from feldspar, but a general description may be of interest, especially in view of some of the more recent attempts. The general experience gained from the study of the decomposition of feldspar on a commercial scale seems to be that the production of potassium salts alone does not pay for the cost of extraction, and, therefore, other products should, if possible, be obtained simultaneously.

Processes have been suggested in which feldspar has been treated, under pressure, with carbonic acid gas, or with steam, or chemicals, with the object of reproducing in an accelerated form those natural processes by which

felspathic material has been decomposed in the earth's crust. These processes, however, and those in which hydrofluoric or hydrofluosilicic acids have been used to effect decomposition, have not proved commercially successful, in the latter case on account of the high price of the acids. Experiments have also been made to volatilise the potassium salts by heating a mixture of finely-ground felspar and a reducing agent, and, although at first these appeared promising, on a large scale great difficulties were met with in collecting the salts from the gases and flue-dust issuing from the furnace. In another class of processes, the felspar is fused with some sulphate and carbon. In Hart's process potassium sulphate is used, and the slag, containing a considerable proportion of sulphides, is treated in closed vessels with dilute sulphuric acid, whereby a very pure, finely-divided silica is thrown down, which is said to be suitable for the manufacture of pottery or of sodium silicate. Alum separates from the solution on cooling, and may be decomposed into the sulphates of aluminium and potassium by means of a solution of potassium sulphide, which is added in slight excess.

The Lawrence Smith method of separating the alkalies from silicates, by heating the silicate with ammonium chloride and calcium carbonate and extracting the alkalies as chlorides from the sintered mass by water, has also formed the basis of certain processes, the ammonium chloride being replaced on a commercial scale by sodium or calcium chloride. The method devised by Cushman (U.S. Pat. 987,436), and supplemented by a method of preparing the mixture for the furnace proposed by Coggeshall (U.S. Pat. 987,554), can be made continuous. One hundred parts of felspar rock are mixed with twenty parts of lime and ground to pass a 100-mesh sieve. The mixture is spread in a thin layer, and a solution of calcium chloride, sufficiently strong to bring about the necessary reactions, is allowed to fall on this in separate drops, each drop causing the fine powder to collect into small aggregates or lumps. These are passed through a rotary kiln, maintained at a temperature below that at which potassium chloride is volatilised. The lumps are strong enough to resist breakage during passage through the kiln, and, after firing, consist of potassium chloride and free lime. The product, after being ground, has been used directly as a fertiliser, but the potassium chloride could, of course, be separated from the admixed lime if necessary.

An interesting circular was recently issued by the United States Bureau of Soils, in which the extraction of potash from silicate rocks was reviewed, and a process described, which is to be subjected to trials on a large scale. It was found that when a mixture of felspar, lime and sufficient calcium chloride to convert the alkalies of the felspar into chlorides, is heated to about 1,400° C., practically all the alkalies are volatilised as chlorides, and that this volatilisation takes place more readily than when felspar and lime are heated alone. It is believed that the volatilised chlorides can be economically collected. Further, the hardened mass left after ignition strongly resembled cement clinker, when the ratio of felspar to lime (part of the calcium being present in the original mixture as chloride and the rest as oxide) was as 1 is to 3. Analysis of the ignited residue also showed that the three main constituents, silica, alumina and lime, were present in amounts which lie within the limits allowed for them in a good Portland cement. Ferric oxide, an ordinary constituent of Portland cement, was absent, but this would no doubt be introduced in sufficient quantity if commercial felspar and lime were used in place of the pure materials. The ratio of silica to alumina in felspar is 3.5 to 1, and is about the same

in clays suitable for the manufacture of cement, so that on these grounds the substitution of felspar, or similar silicates, for clay in the manufacture of cement would be possible. It is also pointed out that, in 1909, 13,000,000 tons of Portland cement were manufactured in the United States, and, assuming that felspar containing 8% of potash were substituted for clay, the annual production of potash in this way would amount to about 400,000 tons, and that the value of this would be about three times the value of the potash salts used in the States in 1909 and about twice the value of the imports during 1911. The suggestion appears promising, and the results of the large scale experiments will be looked for with considerable interest.

THE AUTO-OXIDATION OF ROSIN AND THE YELLOWING OF PAPERS.

By J. F. BRIGGS, A.C.G.I.

Two articles which have recently appeared in the German technical press deal with the auto-oxidation of ordinary rosin or colophony, and the discolouring effect of such changes on papers sized with this substance.

At the last annual meeting of the *Verein der Zellstoff und Papier Chemiker* at Berlin, Professor Klason, of Stockholm, described some of his researches with rosin. In the first place, it was recognised that the resin acids in the crude oleo-resin are totally distinct from those in the manufactured colophony; the former are more readily soluble and undergo auto-oxidation on exposure to air far more rapidly than the latter. In the process of manufacture by the distillation of the natural oleo-resin, an isomerisation of the resin acids takes place under the influence of heat.

In his investigations on colophony, Klason exposed powdered rosin, having approximately the composition of pure colophonic acid, $C_{20}H_{30}O_2$, to the action of sunlight for several weeks in the summer. At the end of the exposure, the rosin had gained about 8% in weight, and analysis indicated almost exactly the formula $C_{20}H_{30}O_2 + O_2$. The product was tested for the presence of an organic peroxide by means of a test devised by Klason himself which depends on the oxidation by the peroxide of mercaptan, or better, of cymene hydrosulphide, the mercaptans being capable of sharp titration with iodine. The oxidised rosin contained no trace of a peroxide, but on repeating the exposure experiments with fresh quantities of rosin, it was found that in the earlier stages of a short exposure of the rosin small quantities of a peroxide could indeed be detected. It must, therefore, be concluded that a peroxide is the primary product of the auto-oxidation, but that subsequently it is changed into a substance having no peroxide properties. A similar type of reaction has been recognised in the auto-oxidation of oil of turpentine.

The colour of the oxidised rosin differed scarcely at all from that of the original; the product was rather less readily soluble in petroleum spirit than before; it was amorphous and yielded amorphous salts; these salts show a tendency to rapid discoloration. The auto-oxidation of rosin takes place very slowly, if at all, in the dark.

In papers sized with rosin and exposed to light and air, the conversion of the finely distributed colophonic acid into auto-oxidised rosin takes place in a few days, and if only traces of basic matters be present to combine with the resin acids the paper gradually turns yellow. On the other hand, so long as the papers are kept in the dark, no oxidation of the rosin takes place.

In Klason's opinion, the auto-oxidation of the rosin is hardly likely to affect the stability of the cellulose in a chemical sense, since the oxidation is complete after a comparatively very short exposure and the peroxides are present only in minute quantities during a small portion of that time. Except for the secondary darkening of its salts, the rosin, once oxidised, appears thereafter to be inert both to light and air. To test the influence of the oxidation on the strength of papers, filter paper was steeped in a chloroform solution of rosin and dried; one portion was then exposed to the light whilst the other was kept in the dark. On testing the tensile strains of the two portions, no alteration could be detected as the result of exposure, but the exposed paper seemed slightly more brittle. It is possible that this brittleness was merely a physical effect of structural alteration of the rosin during oxidation; in any case, these papers contained far more rosin than ordinary engine-sized paper, so that no serious deterioration of the fibre is to be expected under ordinary conditions. Certainly it is not to be feared, as has been suggested, that modern engine-sized papers will fall to pieces after a century or so owing to the auto-oxidation of the rosin. Nevertheless, on account of the discoloration which undoubtedly follows the exposure of rosin-sized papers, containing traces of basic matter, it seems desirable to reduce the quantity of rosin in valuable book-papers to the lowest possible, since it is established from an examination of old books that those containing the least rosin remain in the best state of preservation. Highly-sized papers may look and handle very nicely when new, but they discolour more rapidly than soft-sized papers. Incidentally, Professor Klason has made the observation that paper seems to hold back a small proportion of rosin, presumably in the form of an adsorption compound, so firmly that it cannot be extracted by treatment with solvents.

Another series of researches, dealing generally with the discoloration of paper, but more particularly with the influence of rosin in this respect, was described by V. Schoeller in several numbers of the *Wochenblatt für Papierfabrikation* at the end of 1912. Schoeller likewise recognises that rosin sizing is a very potent factor in the discoloration of papers. It had been thought hitherto, that its darkening action was mainly due to the formation of resinates of iron, owing to the presence of iron salts in the sulphate of alumina used for precipitating the size. Schoeller shows, however, that the action of iron is not the most serious cause of discoloration as it only begins to be perceptible when the proportion of iron in the form of resinate amounts to 0.04% of the total rosin present. This amount is twice as large as is to be expected when sizing under practical conditions with ordinary aluminium sulphate. The main factor in the discoloration of engine-sized papers is the alteration of the rosin itself, an alteration caused by, or at any rate accompanying, the process of auto-oxidation described by Klason. There is a slight difference, however, between the conclusions arrived at by these two independent investigators. Klason considers that the darkening in colour is due to the secondary changes of the salts of the oxidised rosin formed in the presence of small quantities of bases. Schoeller, measuring the degree of oxidation by the fall in the iodine-absorption value of the unsaturated groups, recognises that the rosin is oxidised, but considers that the oxidation affects mainly some constituent which is not concerned in the darkening. Schoeller produces the discoloration rapidly by heating the rosin-sized paper in presence of air at a temperature of 95° C., and estimates the relative tendency to discoloration by the time of heating required to produce

it. His researches having been published before Klason's, he has not taken into account the possible subsidiary influence of basic matters.

Schoeller goes on to show that the iodine-absorption value of a sample of rosin is no measure of its tendency to darken when exposed to hot air, and that the purified resin acids extracted from rosin by aqueous alcohol, are more prone to darken than the original rosin, yet these resin acids have a lower iodine value. Schoeller, further, was able to "stabilise" rosin by treating a solution of rosin soap with chlorine in the form of acidified bleaching powder solution. The treated rosin contained 16.9% of combined chlorine, and its iodine-absorption value had fallen very considerably. This chlorinated rosin can be saponified and used for engine-sizing paper in the ordinary way and, provided the aluminium sulphate employed be reasonably free from iron, it is claimed that the paper sized with chlorinated rosin is perfectly stable and shows little or no tendency to discoloration under the conditions of the test.

Quite apart from the question of rosin-sizing, papers may turn yellow owing to a number of causes which Schoeller has also investigated. In the first place, the blue dyestuff used for tinting the white may fade where exposed to the light, thus exposing the cream shade of the cellulose. In other cases, the bleached cellulose itself may be unstable in colour, especially if the organic residues of the bleaching reaction have not been completely eliminated by thorough washing. Again the cellulose may be chemically modified either before or during the bleaching.

Rosin-sizing apart, papers made from sound rags, bleached with moderately strong liquor, quickly and thoroughly washed immediately afterwards, are as stable in colour as can reasonably be demanded. Old and worn rags, overbleached rags, rags which have lain for a long time before washing out the exhausted bleach residues, yield modified cellulose, which is liable to turn yellow on exposure or storage. Papers prepared from fibres other than rags, such as wood cellulose, straw and esparto, consist in any case of chemically inferior celluloses, by their nature more sensitive to bleach liquor than rag cellulose. Such pulps also contain residues of unsaturated compounds (resins, lignin), which themselves are sensitive to light, and in the purification of these pulps very large proportions of bleaching powder are employed. Consequently the degree of colour-stability to be expected from papers other than pure, sound rag papers is not very high, but with careful manufacture results sufficient for ordinary general purposes are obtainable.

The Billiter Alkali-Chlorine Cells.—Dr. A. J. Allmand recently read a paper on this subject before the Faraday Society. Dr. J. Billiter, of the University of Vienna, has, in recent years, designed two successful types of non-mercury alkali-chlorine cells. The Billiter-Siemens cell has already been described in several places. It has diaphragms, these being placed horizontally instead of vertically, as is usually the case. The floor space needed is greater, but the diaphragms are stabler chemically and the current efficiencies are high. Several installations of this cell are working on the Continent and in America. The Billiter-Leykam cell is a modified bell-jar cell. The cathodes are, however, arranged *underneath* the bell-jar, being contained in porous asbestos hoods to catch the hydrogen.

DEPARTMENT OF METALLURGY AND METALLURGICAL CHEMISTRY AT THE NATIONAL PHYSICAL LABORATORY.

By SYDNEY L. ARCHBUTT, F.I.C., Assistant in the Department.

THE department of metallurgy and metallurgical chemistry is an important section of the National Physical Laboratory. This institution began its work in 1900, in the old residential mansion of Bushy House, at Teddington, under the guidance of its present director, Dr. R. T. Glazebrook, C.B., F.R.S. The rapid growth of the laboratory, which is typified by the fact that its total staff has increased from about 15 to over 150 members, has from time to time necessitated the erection of buildings specially designed and constructed for the special work of each division. Thus buildings for the work of the engineering electro-technics, and metrological departments have been erected.

In considering the work and equipment of this laboratory, it must be borne in mind that it is not a teaching institution, but that its work consists essentially of standardisation, research and investigatory work connected with the great technical industries. In 1906 the chemical and metallurgical work was organised into a separate department, Dr. W. Rosenhain being appointed as first superintendent. The scientific staff of the department then consisted of two assistants, while it now counts a total of eleven.

In 1907 a single-storey block containing laboratories for metallurgical-chemistry research and test work was built, and in 1910-11, through the generosity of Sir Julius Wernher, the Wernher Building, a two-storey block, specially designed for the study and advancement of physical metallurgy, together with additional laboratories for chemistry in connection with aeronautics and road materials were added.

By the east door of the building we enter the single-storey-block devoted to chemistry. North lighting is provided in most of the rooms, which are arranged on either side of a corridor running east and west. On the south side are the main chemical laboratory and separate smaller laboratories for research, alloy analysis, aeronautical chemistry

and Road Board chemistry, fumes being removed from these rooms by an electro-motor, driving a fan connected by means of a trunk with the fume-cupboards. On the north side are laboratories for aeronautical chemistry, electro-chemistry, gas analysis, with a staff-room, assistant's office, and store-room. These rooms are lighted by windows overlooking the orchard and gardens. In addition to these are two smaller rooms, one for the use of sulphuretted hydrogen, and the other accommodating the steam still, and an emergency boiler serving the still, steam ovens and baths. A commodious roof store is arranged over this block.

Immediately on entering is the main chemical laboratory (Fig. 1) chiefly devoted to the analysis of



DR. R. T. GLAZEBROOK, C.B., F.R.S.

steel for Government departments.

Volumetric determinations of sulphur and arsenic are carried out at the central bench, the fume cupboard on which is provided with a down draught. Two main fume cupboards on the south wall serve for solution and evaporations for silicon, check determinations of sulphur, phosphorus and manganese by gravimetric methods, etc. Furnaces and muffles are accommodated on the stone bench on the west wall, provided with a Uralite hood which, by means of two flues on its under side, one communicating with the main ventilating trunk,

serves for the removal of fumes, products of combustion, etc.

The substitution of electrical heating for gas for furnaces, muffles, etc., in this division is now almost complete, and an efficient carbon combustion furnace and muffle have been in use for several years. The heating elements in these furnaces are tubes of vitrified silica wound with platinum ribbon. More recently the principle has been applied to a large hot-plate with considerable success, the ribbon in this case lying across a silica plate.

Fig. 2 shows a view of one of the rooms devoted to chemistry in connection with aeronautics, and gives a general idea of the equipment of the smaller research laboratories. Apparatus, designed by Dr. Rosenhain, and constructed at the National Physical Laboratory, for determining the leakage of hydrogen through balloon fabrics is seen in Fig. 3. Slow currents of pure dry air and pure dry hydrogen are passed through two chambers formed by two dish-shaped castings bolted together and separated by a diaphragm consisting of the fabric to be tested. After passing through this chamber the air is led through a heated combustion tube packed with platinised silica. Any hydrogen which has leaked through the fabric into the air during its passage through the chamber is here converted into steam, which is finally absorbed as

in this division from the 435 ampere-hour battery now possessed by the department and erected in the new Wernher building.

Leaving other rooms in this block and passing



FIG. 2.—CHEMISTRY IN CONNECTION WITH AERONAUTICS.

down the corridor, we arrive, via fireproof and folding doors, in the central hall of the new metallurgical or Wernher building.

Wernher Building.—This two-storey block, owing to the special nature of the work, has been designed with a view to providing a separate room for each kind of work to be carried on, which is roughly divided as follows:—Ground floor: grinding, polishing, etching, microscopy, photomicrography and printing, with an attached bay containing workshop, foundry, moulding and machine rooms. First floor: smaller gas and electric furnaces, accurate pyrometry, and offices of the superintendent and staff. The location of the pyrometry, which does not necessitate such a high degree of steadiness as the photomicrography, on the first floor was made possible by the adoption of a continuous fireproof ferro-concrete construction for this floor, as well as the flat roof above, the whole having been so designed as to allow of the erection of an additional storey without any structural alterations to the existing one.

Considering first the rooms on the ground floor and taking them in the order in which they would be utilised for the processes involved in the microscopic investigation of a specimen of metal, we have first the grinding room equipped with two special grinding machines, each consisting of a horizontal annulus of carborundum, 10 ins. diameter and 2 ins. wide, driven by an electro-motor and worm gearing, one at about thirty and the other at seventy revolu-



FIG. 1.—MAIN CHEMICAL LABORATORY.

water in tared CaCl_2 tubes. Rates of leakage as low as 2.5 litres per sq. metre per hour can be readily detected and measured by this apparatus.

In addition to the lighting circuit at 105 volts, which can be tapped by means of plug points in the rooms, current at from 0—110 volts is available

tions per minute. Hand grinding with emery paper is also provided for in this room. The specimen is then taken, via the corridor, into the adjoining polishing room, where there is a bench carrying four independent horizontal rotating cloth-covered polishing discs, driven by four separate electric motors, each capable of a large range of speed regulation. A portion of this bench is seen in Fig. 4. Communicating directly with this room is the etching room, in which is a large glazed earthenware sink and a bench with fume cupboard. Simple microscopes are provided, by means of which the progress of the polishing and etching is observed. The

small lobby communicates with two dark rooms; afterwards the photographic negative is taken into a printing room provided with a special bench and large sink, where it is printed and stored. An enlarging lantern is available in this room.

Two out of four other rooms on this floor are at present being utilised for special research on iron and steel. In addition to these are a cloak-room and commodious store-room arranged under the staircase leading to the first floor.

The first room on the left at the head of the staircase is the small laboratory for electric furnaces containing the main switchboard of the 435-ampere



FIG. 3.—DETERMINING THE LEAKAGE OF HYDROGEN THROUGH BALLOON FABRICS.

room for visual microscopic examination of the specimen is across the corridor and has a central table accommodating two Rosenhain metallurgical and a Zeiss stereoscopic microscope. This room communicates directly on the one side with a museum for storing specimens, and on the other with the room for photomicrography, in the floor of which, and isolated from it, are two solid concrete blocks, 9 ft. 6 ins. by 4 ft. by 10 ft. deep, on one of which is a Zeiss apparatus provided with a special arc lamp, provision being made by means of a hood over the lamp for withdrawing the noxious gases produced by the powerful arc; special light-tight ventilating shutters close the windows when the apparatus is being used. A view of the room is seen in Fig. 5.

Immediately opposite, across the corridor, a

hour Tudor battery, installed in a special room adjoining; twenty-four independent circuits controlled at this board furnish current up to 110 volts to the various rooms in the building. Two iron benches, one covered with a hood communicating with a flue, on opposite walls of glazed brick are provided for the furnaces, and are designed and made in the department. From several points over the furnace benches independent sets of leads are provided, making continuous unbroken connections between the cold junctions of the various thermocouples in use at the furnaces and the delicate potentiometric measuring instruments in the adjoining room, where records of the time intervals of heating or cooling are obtained by means of a chronograph and standard clock. The equivalent scale length for 1,000° C. of one of the instruments

set up in this room is over 15.5 metres, and the accuracy attainable may be judged from the fact that by most recent methods a melting point has been repeated to within 0.2° C. Communicating directly with this room on the other side is the laboratory for small gas furnaces. High pressure air at 100 lbs. per sq. in. is available at several points on the benches. For high temperature furnaces the air at this high pressure is utilised for inducing a much larger volume of air by means of an injector before it meets the gas. One of these injector burners, designed by the Superintendent, using high pressure air and gas, raised the interior of a small injector furnace to a brilliant white heat in ten minutes, starting all cold.

Returning to the ground floor, a short corridor leads from the main corridor to an attached bay containing the work-shop, foundry, moulding shop and machine room.

special researches. A short corridor, on either side of which are the moulding shop and machine

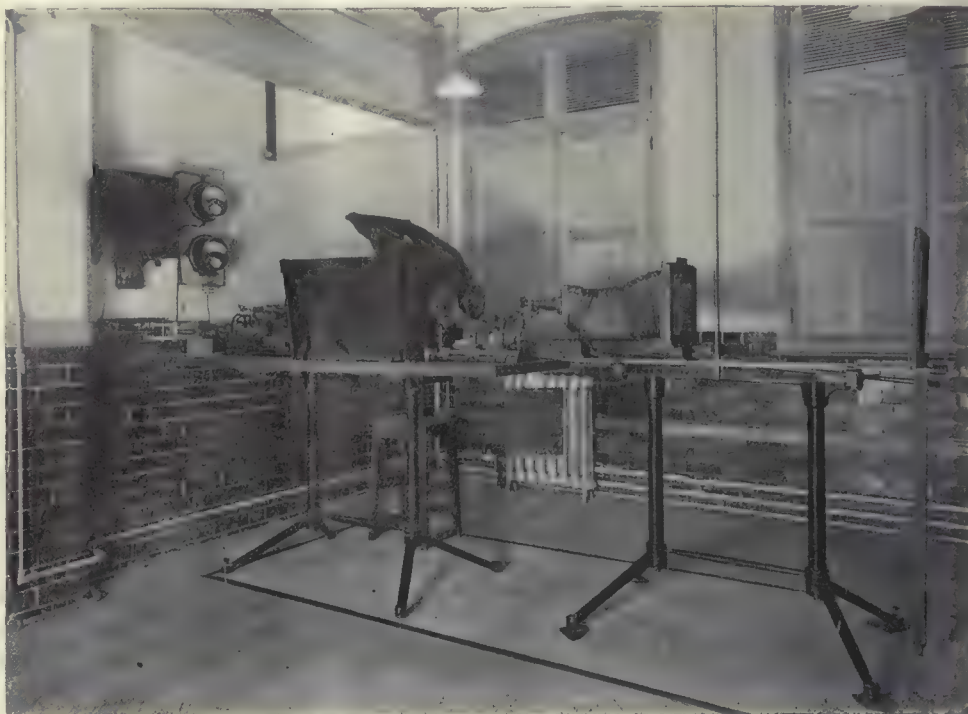


FIG. 5.—ROOM FOR PHOTOMICROGRAPHY.



FIG. 4.—POLISHING ROOM.

The workshop is at present equipped with a power hack-saw, small metal working lathe and tool bench, but it is intended as soon as funds permit, to instal testing machines required for

work, leads to the foundry (Fig. 6), lofty and well ventilated, provided with a 3-ton travelling crane. Two natural draught, gas-fired, crucible furnaces are here set up, having capacities of about 70 and 30 lbs. of brass respectively. Compressed air mains are installed and a gas or oil-fired furnace will shortly be set up, in which the high pressure air will be used in one of the special injector burners mentioned above.

Ultimately, it is hoped that funds will be found for the installation of a small rolling-mill plant in this bay, which would be of great service in such work as the alloys research carried on by the department on behalf of the Institution of Mechanical Engineers. In the machine room an electro-motor supplies power to a small Reavell compressor connected with a reservoir of 100 cub. ft. capacity, and the power hack-saw, etc., in the workshop.

Work of the Department.—Like the rest of the laboratory, this department undertakes, in addition

to standardisation and research, a certain amount of investigatory work and also, for some Government departments, some routine testing. Private firms or individuals who desire to avail themselves of the services of the laboratory are required to sign a special form, declaring that the work required is of an investigatory nature. Some of the investigations which have been undertaken by the department include cases of boiler explosions and cracking of plates, failures in shafts, rails, tyres, axles, etc., pitting and corrosion of condenser tubes, behaviour of alloys at high temperatures, critical points of steel and alloys, etc. A large amount of this work involving chemical analysis, microscopic examination and mechanical testing is carried out in conjunction with the engineering department of the laboratory, where drillings for analysis are taken,

taneous combustion was found to occur when the oven temperature reached 96° — 110° C., according to the rate of air supply, but at lower temperatures there was no sign of spontaneous heating. On mixing 5% of sulphur dioxide with the air, however, the startling result was obtained, that even at the ordinary temperature spontaneous combustion took place when the charcoal had been exposed to a current of such air for hours.

A considerable amount of chemical and metallurgical work, such as chemical analyses and tests, making of special alloy castings, etc., is carried out for other departments of the laboratory.

Research.

In conclusion, brief mention may be made of some of the principal lines of research.



FIG. 6.—FOUNDRY.

and test pieces for the various mechanical tests are cut, machined and tested. Advice is frequently asked for and given on matters which come within the scope of the work of the department, such as the composition and heat treatment of steel, selection of suitable alloys for special purposes, questions of general foundry practice, etc.

Investigations connected with difficulties encountered in industrial processes have also been undertaken on behalf of those interested.

The inflammability of flake charcoal has recently been the subject of an investigation in this department on behalf of Lloyd's register. Quantities of a cubic foot of the material were tested in a large, electrically-heated oven, designed and built in the Laboratory. Air was supplied to the charcoal at rates varying from 5—62 cub. ft. per hour. Spon-

Alloys research on behalf of the Alloys Research Committee of the Institution of Mechanical Engineers, and embodied in the 7th, 8th, 9th and 10th Reports has been carried out by the department. Of these, the 9th, on the alloys of copper, aluminium and manganese, and the 10th on the alloys of aluminium and zinc, have been carried out under the direction of the present Superintendent, Dr. Rosenhain.

This work which, with the exception, perhaps, of the investigation of the thermal equilibrium, is of an essentially practical nature, includes the preparation of the alloys by the melting together under proper conditions of the constituent metals; the casting of the alloys into the form of billets and slabs for the purpose of rolling and drawing into bar, sheet, and wire, and of small chill billets and sand

castings for tensile tests; the breaking down of the billets and slabs, and the rolling and drawing into bar, wire, and sheet; and finally, the thorough mechanical testing of the material obtained both in an annealed and an unannealed condition.

The mechanical tests include tensile tests at ordinary and at elevated temperatures, determination of elastic modulus, torsion tests, Brinell and scleroscope hardness tests; alternating-stress, repeated bending impact and Izod impact tests, etc. For gifts of the necessary metals and facilities for the rolling and drawing operations in these reports the laboratory is indebted to several private firms, particularly Messrs. the Broughton Copper Co. and Messrs. the British Aluminium Co., at whose works every facility for the breaking down of the billets and slabs in the presence of the authors of the reports has been given.

Metallographic researches include redeterminations of the equilibrium diagrams of the systems lead-tin¹ and aluminium-zinc,² the latter investigation leading to a considerable modification of the generally accepted diagram, and the discovery of a compound of aluminium and zinc having a composition represented by the formula Al_2Zn_3 .

Research in connection with the nature and properties of crystals and crystalline aggregates is in progress, and several papers have been published recently. One of these, entitled "The Inter-crystalline Fracture of Iron and Steel,"³ embodies the results of work on the nature and production of weakness of the crystal boundaries, whereby, instead of the usual cleavage fracture, rupture occurs at the crystal boundaries themselves. In a paper entitled "Intercrystalline Cohesion in Metals,"⁴ considerable evidence is afforded for the hypothesis of an intercrystalline cementing material of an amorphous nature. Such a material should be more active chemically and physically than the

crystals themselves. It might, for instance, be expected to be more volatile, and experiments recorded in the paper show that the rate of loss of weight *in vacuo*, of fine-grained specimens of metal which presumably contain more of the amorphous material, is greater than that of coarse-grained specimens which contain less. Other properties which would be expected of such a material are being investigated, and interesting results are forthcoming.

The effect of strain at high temperatures on iron and steel has been the subject of research for some time past. Early experiments were begun with the object of extending previous observations on slip-bands to high temperatures. Specimens of pure iron in the form of thin strip, polished for microscopic examination, were enclosed in an air-tight vessel which was exhausted to a high vacuum. The arrangement then made it possible without disturbing the vacuum to heat the specimen electrically and subsequently to release a spring which applied strain to the specimen. This was then allowed to cool down in the evacuated vessel, and remained perfectly bright and untarnished for subsequent microscopic examination.

The results⁵ of this preliminary work extended the generalisation as to the mode of deformation of metals by intra-crystalline slip, up to temperatures of $1,100^\circ\text{C}$. for pure iron, and afforded a demonstration of the existence of three distinct allotropic modifications of iron in accordance with the theories of Osmond—Roberts-Austen.

A more complete and elaborate apparatus has now been designed and erected, by means of which accurately known stresses can be applied to thin strips of metal while heated *in vacuo* of the order of 0.001 mm. of mercury, in a small electric tube furnace. The arrangement permits of any desired rate of loading, and produces autographic stress-strain diagrams. An account of this accurate quantitative work is in preparation and will shortly be published.

¹ *Phil. Trans.*, Vol. CCIX., pp. 89—122.

² *Phil. Trans.*, Vol. CCXI., pp. 315—43.

³ *Carnegie Scholarship Memoirs*, Vol. IV., 1912.

⁴ *Journal of the Institute of Metals*, No. 2, 1912, Vol. VIII.

⁵ *Proc. Royal Society, A.*, Vol. LXXXIII., 1909.

NOTES OF MEETINGS.

CHEMICAL SOCIETY.

April 3rd and 17th, at 8.30 p.m. Ordinary Meeting.

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SOCIETY OF CHEMICAL INDUSTRY.

London Section:—April 7th, at 8 p.m.

* * *

THE ROYAL INSTITUTION.

April 4th, Professor James J. Dobbie, M.A., LL.D., F.R.S., "The Spectroscope in Organic Chemistry," at 9 p.m.

April 7th, General Meeting, at 5 p.m.

April 18th, Thomas Martin Lowry, D.Sc., F.C.S., "Applications of Polarised Light" (with experiments), at 9 p.m.

SOCIETY OF ARTS.

April 2nd, Prof. Vivian B. Lewes, F.I.C., F.C.S., "The Testing of Safety Explosives," at 8 p.m.

April 21st and 28th, David Somerville, B.A., M.D., D.P.H., "Antiseptics and Disinfectants," at 8 p.m. (Cantor Lectures).

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INSTITUTION OF CIVIL ENGINEERS.

April 1st, 8th, 15th and 22nd, at 8 p.m. Ordinary Meetings.

* * *

INSTITUTION OF MECHANICAL ENGINEERS.

April 17th, Anniversary Dinner.

April 18th, General Meeting, at 8 p.m.

MOLECULAR PHYSICS.

By J. A. CROWTHER, M.A. (Fellow of St. John's College, and Demonstrator in Physics in the Cavendish Laboratory, Cambridge.)

CHAPTER III.

THE POSITIVE PARTICLE.

WE have already seen that positively charged particles are projected with high velocities from radium and other radioactive substances, and that they are also to be found in discharge tubes. Unlike the electron the positive particle has a mass comparable with that of an atom, no positive charge having yet been detected in association with any mass less than that of an hydrogen atom. The charge on a positive particle is, however, either the same as that on an electron or some simple multiple of it. The α -rays, as the particles from radioactive substances are still called (a relic of the time when their nature was unknown) always carry a charge of $2.e$. In discharge tubes, however, positive particles are found with all integral multiples up to $8.e$. We shall see that we may regard the positive particles as atoms travelling with a high speed from which one or more electrons have been removed.

The positive particle can be deflected by electric and magnetic fields in the same way as the negative electron, and obeys the same laws. The deflection is in each case in the opposite direction to that of the electron, while, owing to the greater mass, the deflection is less than that for a similarly moving electron. The great ionising power of the positive particles makes the detection of the electrical deflection difficult. For these and other experimental reasons it is only recently that much light has been thrown on their nature and properties. These difficulties have now been overcome, and the positive particle also is beginning to yield up its secrets. As the positive particle is always an atom of some kind, its investigation is, perhaps, from some points of view of even greater interest than that of the electron.

The greater energy of these particles is, however, in some ways an advantage. It enables us to deal with individual particles, whereas in the case of the electron we can only deal with large numbers. Thus our measurements gain, perhaps, in definiteness although they may lose somewhat in numerical precision.

If e be the charge on a single α -particle, the total charge carried by N particles is $N.e$, and if N is sufficiently large this charge will be large enough to be directly measured by an electroscope or electrometer. If we can further determine the number of particles carrying this charge we shall have made a direct determination of the charge e .

The experiments are best performed using the α -particles from radium, polonium, or some other radioactive substance. They were carried out almost simultaneously by Rutherford, and by

Regener. In Rutherford's experiments the α -particle was detected by the ionisation it produced in a special chamber; the entry of each α -particle into the apparatus being notified by a kick of the needle of a sensitive electrometer. In Regener's experiments the number of scintillations produced by the particles in a given time on a fluorescent screen was counted. The former method was the more satisfactory from a theoretical view, as there was at the time no direct evidence that every particle produced a scintillation when it struck a screen, although this has since been shown to be the case by Rutherford. It was also proved by the fact that the two experimenters reached almost exactly the same value for the charge on the α -particle. The experiment of Regener is simpler to carry out than the electrical

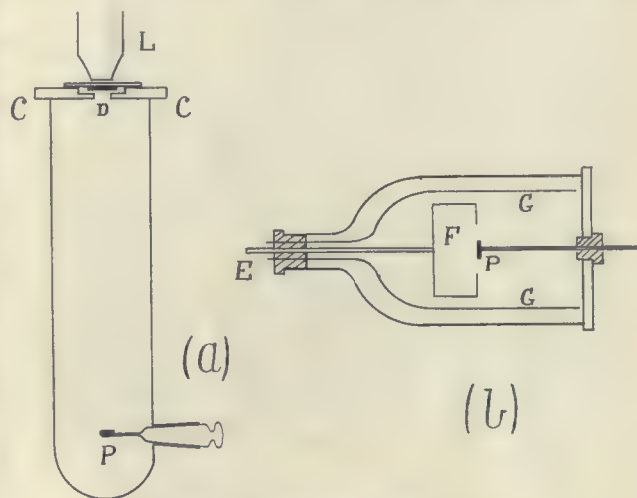


FIG. 7.—REGENER'S APPARATUS.

method of Rutherford, and granting his assumptions, is probably capable of greater accuracy.

Regener's apparatus is shown in Fig. 7. Fig. 7a shows the "counting" apparatus, Fig. 7b, the apparatus for measuring the total charge carried by the rays.

The counting apparatus is very simple. It consists of a long tube closed at one end by a brass plate c, c , bored with a circular hole some centimetre in diameter. Across this is sealed a thin glass cover-slip bearing on its under surface the fluorescent screen D , in this case a thin plate cut from a crystal of brown diamond, a substance chosen by Regener after many trials as the most suitable for the purpose. Rutherford has since used prepared screens of powdered willemite with equal success.

A high power microscope was focussed on the diamond plate for viewing the scintillations which, numbering about one every two seconds, were easily counted. The source of the α -particles in

Regener's experiments was a plate of polonium, placed at P, some 12.7 cms. from the diamond screen. The whole tube was carefully exhausted so that there should be no absorption of the particles before reaching the screen.

The number of scintillations in a given time was counted, and the area A of the aperture in the brass plate and its distance R from the polonium carefully determined. If n is the number of particles hitting the screen in a time t seconds, then the number of particles emitted by the polonium per second across a hemisphere drawn about its upper surface is

$$N = \frac{2\pi R^2}{A} \cdot \frac{n}{t},$$

assuming that the particles are given out equally in all directions. This assumption was verified by Rutherford in a separate experiment. For the disc used by Regener N was found to be 3.935×10^6 .

To measure the total charge carried by the α -particles from the disc a Faraday cylinder was used. This consisted of a partially closed brass cylinder F (Fig. 7b) enclosed in a glass chamber exhausted to a very high vacuum to avoid any loss of charge by ionisation in residual air. The polonium was mounted at P so that the α -particles from its upper surface entered the cylinder. Here they gave up their charges to it, gradually raising it to a positive potential, which could be measured by an electrometer or electroscope connected to the metal electrode E.

This method of measuring small currents by the electrometer is one in every-day use in this class of experimental work and deserves a little further consideration. Let C be the electrical capacity of the Faraday cylinder and its connections, and suppose the cylinder is placed at zero potential by connecting it to earth. Insulate and note the reading after some suitable interval of time, say t seconds. Let V be the potential corresponding to this reading; this can easily be determined by calibrating the instrument with suitable known potentials. The charge given to the electrode in the time t is then CV , so that the current between P and F is CV/t .

Since the capacity of a system can be made very small the method is far more sensitive than the most delicate galvanometer. The capacity of an electroscope of the C. T. R. Wilson type with its electrode and all its connections need not be greater than 4 or 5 cms.; or, say, 5×10^{-12} farads. The electroscope will easily give a deflection of 100 divisions for a potential of 1 volt, while a movement of the gold leaf of a division per minute can be detected with certainty. This corresponds to a current of 10^{-15} amperes. The best galvanometers give a perceptible deflection for a current of about 10^{-11} amperes. The electroscope method is, therefore, about ten thousand times as sensitive as the most delicate galvanometer.

In the present case the value of CV/t gives the charge carried by the α -particles per second from the upper surface of the polonium disc. In electrostatic units it was found to be .000377. This was the charge carried by the 3.935×10^6 α -particles emitted by the polonium. The charge on each

particle was therefore .000377/.3935 $\times 10^6$ or 9.58×10^{-10} in electrostatic units. Rutherford's value was 9.30×10^{-10} in the same units.

It will be seen that these numbers are almost exactly twice the value 4.7×10^{-10} e.s.u., which represents the mean value for the electronic charge e . In fact the value of $2 \cdot e$ is almost midway between these experimental numbers. The charge on the α -particle is therefore exactly twice the charge on the electron. The α -particle is therefore an atom which has lost two electrons. This is characteristic of all the α -particles emitted by radioactive substances which appear to differ from each other only in velocity.

We have stated that the α -particle is an atom; the question arises of what element is it an atom? The ratio of the mass to the charge can be determined for the α -particle in the same way as for the electron, neglecting the different experimental arrangements required. No great accuracy has, however, been reached, as the deflection of these particles from radioactive substances even in the strongest magnetic fields is small. According to Rutherford, the ratio of mass to charge for the α -particle from radium is 1.97×10^4 , and we have seen that they carry two charges, or in the language of electrolysis, are divalent. The electrochemical equivalent of hydrogen is 10^4 , so that if we can assume that the ion in solution carries the electronic charge e , the atomic weight of the α -particles would be 3.84, which is very near 3.96, the atomic weight of helium. Conversely, if we can show that the α -particle is an atom of helium we shall have direct evidence that our assumption that the monovalent ion carries the same charge as an electron is correct.

The proof of the nature of the α -particle has been given by Rutherford to whom we owe so much of our knowledge of these rays. The experiment is based on the fact that the α -rays, owing to the great speed with which they are projected by the parent molecule, are able to pass through thin sheets of solid substances which are perfectly impervious to the molecules of ordinary gases.

The substance used as the source of α -particles was radium emanation, the radioactive gas which is the first decomposition product of radium, and on which Professor Ramsay proposes to bestow the name of niton. This gas, which is disengaged from solutions of radium in water, after being purified in various ways, is finally passed into a fine thin-walled glass tube, the end of which has been carefully sealed. This is enclosed by a wider thick-walled glass tube which is also made quite air-tight and has in its upper portion two electrodes. The spectrum of the discharge between these two electrodes enables us to determine the nature of the gases in this outer tube. There is no connection between the inner and outer tubes, so that nothing can pass from the one to the other, except the α -rays. This point was tested by filling the inner tube with helium and allowing the apparatus to stand for some days. No trace of the helium spectrum was obtained in the outer tube under these circumstances. When, however, the inner tube was filled with emanation, the

α -particles emitted were able to pass through the thin glass walls and, being stopped by the thicker tube beyond, collected in the space between the two tubes.

Slowly, as the experiment went on, the spectrum of helium began to appear, becoming brighter and more complete as more and more of the rays passed through the inner tube, until at the end of a few hours the complete helium spectrum was obtained. The blank experiments were far more in number and severity than has been described here. They left no doubt that the α -particles were indeed atoms of helium, differing from the ordinary atoms of the gas only in their velocity and charge. We have seen above that this result leads directly to the conclusion that the charge on a monovalent ion in solution is the atom of electricity which we denote by e .

This is one of the most direct proofs of this very important fact. There are, however, many others of very diverse natures, some of which we shall have occasion to discuss when dealing with the phenomena on which they are founded.

The charge carried by a monovalent ion in solution and the electronic charge are thus the same; the value for the latter is, as we have seen, very near 4.7×10^{-10} e.s.u., or 1.57×10^{-20} in our electromagnetic units. The ratio of the mass to the charge for the hydrogen atom is, as we have seen, 1.04×10^{-4} . Thus the mass of the hydrogen atom is $1.04 \times 10^{-4} e$, or 1.63×10^{-24} gms. This is therefore the value in grammes of the chemical unit of atomic weight, and we can at once calculate from it the actual mass of any atom of which the chemical atomic weight is known. The accuracy of the result depends only on the accuracy with which the value of e can be determined. A reference to Table II. (see page 92) will show that the error in the value we have used probably does not exceed 2%, or 3% at most.

Since the mass of a cubic centimetre of hydrogen at normal temperature and pressure is almost exactly 9×10^{-5} gms., the number of hydrogen molecules contained in 1 cub. cm. of a gas under these conditions is $9 \times 10^{-5} / 2 \times 1.58 \times 10^{-24}$, or 2.75×10^{19} . By Avogadro's hypothesis this number is independent of the nature of the gas.

CHAPTER IV.

THE NEW METHOD OF ANALYSIS.

WE have considered so far the case of the positively charged particles from radioactive substances, and have seen how their mass, charge, and chemical nature have been determined, and how these determinations have given us the most certain and accurate estimate of the actual mass of a hydrogen atom. The information obtainable was, however, limited by the fact that these particles are all of one kind, consisting always of atoms of helium.

We have already mentioned that it is possible, in a discharge tube, to endow atoms and molecules of ordinary matter, with those properties of high velocity and electric charge which have made the

α -particles so amenable to experiment. The process may be regarded as follows. When the two electrodes of the discharge tube are connected to the poles of an induction coil, the molecules of the rarefied gas in the tube are subjected to a very strong electric tension. This tension acting upon the negative electrons, which, as we have seen, are contained in all molecules, causes one or more of them to be displaced from the molecule, leaving the remainder positively charged. This positive particle, as we may now call it, is driven with great velocity towards the cathode by the action of the electric field which produced it.

If the cathode is suitably perforated, the positive particle will pass through it, and emerge on the further side with this velocity unimpaired. It can then be detected by allowing it to fall either on a fluorescent screen, or preferably on a photographic plate, where it will produce a permanent record,

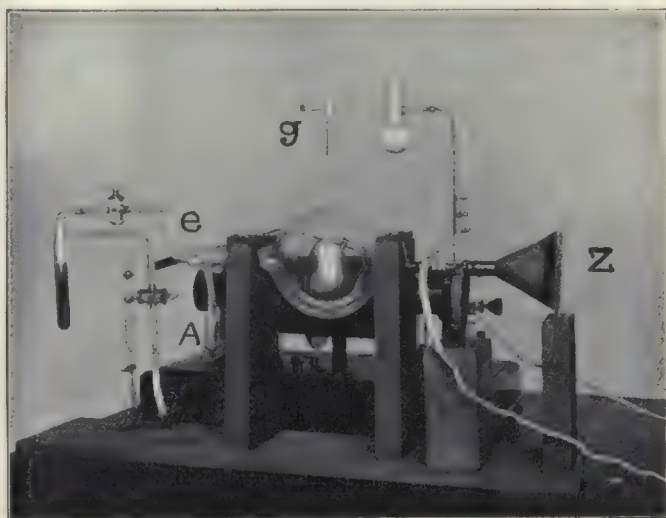


FIG. 8.—THOMSON'S DISCHARGE TUBE WITH "CAMERA" ATTACHMENT.

which can be measured at leisure with suitable instruments of precision.

The experiments, for reasons to which we have already alluded, presented many difficulties. It is only after several years of experiment that Professor Sir J. J. Thomson has at last perfected an apparatus which allows him to measure these particles with accuracy and certainty.

A general idea of the apparatus can be obtained from Fig. 8, which is reproduced from a photograph of one of Professor Thomson's tubes. The details are shown more clearly in the accompanying diagram, Fig. 9, which represents a section of part of the apparatus as seen from above.

The apparatus consists of two parts: the discharge tube proper, where the particles are produced, and the "camera," where their presence is detected and their masses determined. The discharge tube proper consists of a large bulb T, some 30 cms. in diameter. The anode A (Fig. 8) is placed in a side tube, while the cathode C (Fig. 9) occupies the neck of the

bulb. The gas to be experimented on enters the bulb through the tubes at *e*, and is removed through the tube *g* by a Gæde pump, which is worked sufficiently rapidly to keep the gas in *T* at a suitably low pressure.

The cathode *C* (Fig. 9) is an aluminium rod pierced with a very fine copper tube about 8 cms. long and less than 1-10th mm. in diameter. An exceedingly fine pencil of positive rays is thus obtained. It is evident that with a tube so narrow any stray magnetic field will cause the particles to hit the walls of the tube and be lost. To prevent this the copper tube is enclosed for the greater part of its length in a thick iron tube *S*, shaded in the diagram, while thick iron screens *I, I*, protect the main discharge from the influence of the magnet.

Owing to the intensity of the discharge, the cathode becomes very hot, and it is necessary in order to protect the numerous sealing wax joints, to surround them with a water cooling jacket, as shown in Fig. 8.

On leaving the copper tube, the rays pass between *M* and *N*, two soft iron blocks let in through the sides

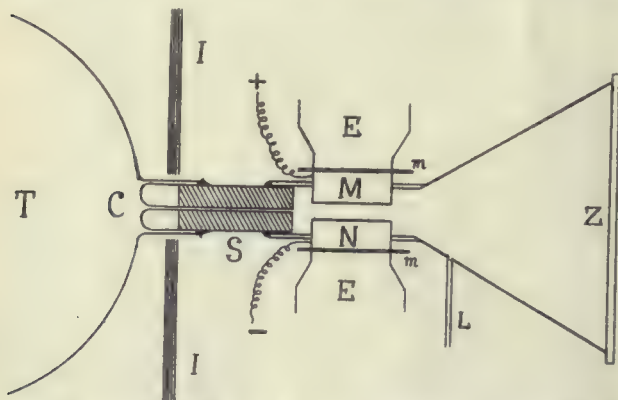


FIG. 9.—DISCHARGE TUBE WITH "CAMERA" ATTACHMENT (SECTIONAL).

of the tube (which is here made of ebonite) and carefully waxed round, so as to be completely vacuum tight. These blocks serve two purposes. In the first place, they form the pole pieces of the electromagnet *E, E*, from which, however, they are electrically insulated by two thin strips of mica *m, m*. This insulation enables them to be charged positively and negatively respectively, by means of a cabinet of small storage cells, and thus to serve as electrodes for the application of an electrostatic field.

In this way the positive particles can be subjected at the same time to a magnetic and an electric field. It will be noticed that, whereas in the case of the cathode ray experiments described in an earlier chapter the two fields were at right angles to each other, in this case the two fields are parallel, and the corresponding deflections therefore at right angles to each other.

After passing through these fields, the rays fall either upon the glass plate *Z*, which is covered with powdered willemite, or upon a photographic plate, which can be introduced when required immediately in front of *Z* by suitable devices.

The side tube *L* leads to a tube filled with charcoal and immersed during the experiment in liquid air, a device due originally to Sir James Dewar for absorbing as completely as possible the gases in this part of the apparatus. This detail, apparently insignificant in itself, has had much to do with the success of the method. If the gas in the camera is at the pressure most suitable for the production of positive rays in the discharge tube, the effects observed on the screen are found to be almost entirely secondary. The residual gas in the camera becomes strongly ionized by the action of the positive rays upon it. The latter are thus travelling through an atmosphere charged with negative electrons, with which they readily combine to form neutral molecules again. When this has taken place, the particle is no longer acted upon by electric or magnetic fields. The exact extent of its deflection will depend upon the length of time during which it succeeded in retaining its charge. These secondary effects still make their appearance upon some of the photographs taken. They can, however, always be detected by the fact that they either disappear or alter in position or appearance, if the pressure in the camera is slightly lowered or slightly raised.

The charcoal and liquid air method enables us to remove the residual gas so rapidly that it is possible to have the pressure in the camera considerably lower than that in the discharge tube, the diffusion along the long narrow copper tube, which is their only connection, being comparatively slow. In this way the production and the measurements of the particles can both be carried on under the most favourable conditions.

Let us consider the course of the positive particle from its genesis in the discharge tube to its stoppage on the photographic plate. Particles formed near the anode will fall through practically the whole of the difference of potential between the electrodes of the discharge tube, some 30,000 or 40,000 volts. The energy they acquire will thus be $V \times E$ where V is this difference of potential, and E the charge on the particle. Their velocity v , on reaching the cathode, will thus be given by

$$v^2 = 2VE/m.$$

This is the maximum velocity the particles can attain. Those commencing their existence nearer the cathode than this, only fall through a fraction of the full potential V , and thus acquire only a fraction of this maximum velocity. Thus, the stream of rays passing through the cathode will contain particles moving with all velocities up to a certain maximum.

On passing into the electric and magnetic fields at *MN* they will be acted upon by forces equal to XE and HEv respectively where X is the electric and H the magnetic field, exactly as in the case of the cathode particles, the only difference being that the directions of the deflections will be in the opposite directions to those of the negative particles. It can be shown that these forces will cause the point at which the particle strikes *Z* to be deflected through distances equal to $k_1 \frac{HE}{mv}$ in the case of the magnetic

field, and $k_2 \frac{XE}{mv^2}$ in the case of the electric field, k_1 and k_2 being constants which depend only on the relative dimensions of the various parts of the apparatus. It must be remembered that the fields have been so disposed that these two deflections will take place at right angles to each other.

(To be continued.)

PERSONAL AND OTHER NOTES.

(The Editor will be pleased to receive notices of appointments, etc., for publication in this column.)

THE elected officers and members of Council of the Institute of Chemistry for the forthcoming year are as follows:—*President*: Raphael Meldola, F.R.S. *Vice-Presidents*: George Thomas Beilby, F.R.S.; George McGowan, Ph.D.; Sir Alexander Pedler, F.R.S.; Sir Boverton Redwood, Bart., D.Sc.; Sir William Augustus Tilden, F.R.S.; Edward William Voelcker, A.R.S.M. *Hon. Treasurer*: Alfred Gordon Salamon, A.R.S.M. *Members of Council*: Leonard Archbutt; Francis William Frederick Arnaud; Edward John Bevan; Bertram Blount; Arthur George Bloxam; Cecil Howard Cribb, B.Sc.; William Salvador Curphey; Cyril Dickinson, B.Sc.; William Porter Dreaper; Martin Onslow Forster, F.R.S.; Sir Richard Garton; Frank William Harbord, A.R.S.M.; Arthur Harden, F.R.S.; Otto Hehner; Charles Alexander Hill, B.Sc.; Edward Hinks, B.Sc.; William Macnab; Gordon Wickham Monier-Williams, B.A., Ph.D.; William Henry Perkin, LL.D., F.R.S.; Thomas Slater Price, D.Sc.; Sylvester Oliffe Richmond; Clarence Arthur Seyler, B.Sc.; Thomas Stenhouse, junr., B.Sc., A.R.S.M.; Frederick Wallis Stoddart; Oliver Trigger; James Woodward, B.A., B.Sc.; Sydney Young, D.Sc., F.R.S.

The new Council of the Chemical Society consists of the following members:—George Barger, M.A., D.Sc.; Edward John Bevan; William Robert Bousfield, M.A., K.C.; Adrian John Brown, M.Sc., F.R.S.; Harold Govett Colman, D.Sc., Ph.D.; Frederick George Donnan, M.A., F.R.S.; Arthur Harden, F.R.S.; Thomas Martin Lowry, D.Sc.; Hugh Marshall, D.Sc., F.R.S.; Kennedy Joseph Previté Orton, M.A.; Sir Boverton Redwood, Bart., D.Sc.; Edward John Russell, D.Sc. Professor W. H. Perkin, Sc.D., LL.D., F.R.S., is the new President. Professor Crossley resigns as Joint Secretary and becomes Foreign Secretary. Dr. J. C. Philip takes his place as Joint Secretary with Dr. S. Smiles.

The elected officers and members of Council of the Society of Public Analysts for the forthcoming year are as follows:—*President*: Leonard Archbutt, F.I.C. *Vice-Presidents*: George Embrey, F.I.C.; J. T. Hewitt, M.A., F.R.S.; W. H. Willcox, M.D., F.I.C. *Hon. Treasurer*: Edward Hinks, F.I.C. *Members of Council*: R. M. Clark, F.I.C.; James Connah, F.I.C.; John Evans, F.I.C.; George T. Holloway, F.I.C.; G. D. Lander, F.I.C.; Thomas Macara, F.I.C.; G. W. Monier-Williams, M.A., F.I.C.; Cecil Revis; Harry Silvester, F.I.C.; F. Wallis Stoddart, F.I.C.; Arnold R. Tankard, F.I.C.; John White, F.I.C.

The following candidates have been selected by the Council of the Royal Society to be recommended for election into the Society:—Professor V. H. Blackman, Dr. William Bulloch, Mr. D. L. Chapman, Professor W. E. Dalby, Dr. T. R. Elliott, Professor J. C. Fields, Dr. J. S. Flett, Professor J. P. Hill, Mr. A. R. Hinks, Professor F. Keeble, Professor A. Keith, Dr. K. Lucas, Professor O. W. Richardson, Dr. W. Rosenhain, and Mr. G. W. Walker.

We are informed that Mr. Emil Hatschek and Mr. L. Simon have been awarded the "Consolidated Gold-fields of South Africa, Ltd." premium of 40 guineas, by the Institution of Mining and Metallurgy for their paper on "Gels in relation to Ore Deposition."

The Society of Dyers and Colourists has appointed a special Committee to report on the valuation of malt extracts for textile purposes. The Committee consists of W. P. Dreaper (Chairman), Dr. Frankland Armstrong, C. F. Cross, F. J. Farrell, Dr. Herz, W. E. Kay, T. H. Pope and M. C. Lamb (convenor).

It has been decided to form an Oil Engineers' Association, and Sir Fortescue Flannery, M.P., Mr. W. Bruce Dick, Mr. D. A. Sutherland, and Sir Boverton Redwood have been asked to constitute a sub-committee to consider the formation of a council.

The Petrol Substitutes Committee of Investigation, composed of Mr. Bertram Blunt, Mr. W. Worby Beaumont, and Mr. E. Shrapnel Smith, on behalf of the Royal Automobile Club; Mr. C. H. Dodd, Mr. W. Ballin Hinde, and Mr. Charles Temperly, on behalf of the Automobile Association and Motor Union; and Mr. Edward Manville, Mr. David Citreon, and Mr. S. F. Edge, on behalf of the Society of Motor Manufacturers and Traders, is now constituted, and has had its first meeting at which Mr. Stenson Cooke, Secretary of the Automobile Association, was appointed Hon. Secretary. The bodies concerned have put up £1,000 for the purpose of thrashing out the vexed question of petrol substitutes.

CURRENT LEGAL TOPICS.

A STUDY IN TOXICOLOGY.

By WILLIAM JAGO, F.I.C.

THE Hove veronal mystery has not merely attracted considerable public attention, but it is also fraught with interest to the student of forensic chemistry. For the latter reason, a review of some of its more salient features may appropriately find a place in these pages.

Dr. Spilsbury, who conducted the *post-mortem* deposited that the organs of the body were normal, and disclosed no cause of death. The appearances were consistent with veronal poisoning. The weights of the more important organs were given by him.

Dr. Willcox confirmed the statement that the organs showed no signs of disease that would account for death. He made analyses of the various organs and found veronal in them all. In the subjoined Table are given the weights of the various organs as ascertained by Dr. Spilsbury, and the amounts of

veronal found in each. The weight of veronal in grains per lb. in each organ is also given.

Organ.	Weight.	Total Weight of Veronal.	Veronal in Grains per lb.
Stomach	8 ozs.	0.8 grs.	1.6
Stomach contents	1 1/4 ozs.	0.28 "	3.58
Intestines	3 lbs. 8 1/4 ozs.	2.87 "	0.81
Liver	2 lbs. 6 1/4 ozs.	2.0 "	0.83
Kidneys	9 ozs.	0.56 "	0.99
Brain	2 lbs.	1.28 "	0.64
Blood-stained fluid in body	9 ozs.	0.87 "	1.55
Totals	9 lbs. 10 ozs.	8.66 grs.	Average 0.87

The above figures in the first two columns are taken from the writer's personal note, and agree with those given in the most detailed newspaper report. The total amount found, 8.66 grs., is the same as the total given by Dr. Willcox. He, however, gave 9 lbs. 14 1/4 ozs. as the total weight of the organs examined. The slight discrepancy is probably due to some one or more of the figures being imperfectly heard. The weight in grains per lb. has been calculated by the writer. Dr. Willcox states that veronal is a poison that becomes distributed practically all over the body and therefore the quantity he found multiplied according to the weight of the body would give something like the amount present in the whole body. He estimated the body to weigh between 10 and 11 stones (140 to 154 lbs.). Omitting the amounts present in the stomach contents and the blood-stained fluid, the total veronal found was 7.58 grs.; the weight of the substances containing this quantity was 9 lbs. (less 1/4 oz.), and from these figures Dr. Willcox deduced 75.8 grs. as the weight of veronal in the whole body. Evidently this figure was not ascertained by any calculation in proportion, since if 9 lbs. contained 7.58 grs., 140 lbs. would proportionately have contained 118 grs. Roughly, the witness subsequently put the weight of the body at 150 lbs. which figure would have in the same way given 226 grs. of veronal.

Unfortunately from the standpoint of the toxicological student, the analytic data were accepted without reserve, and were not made the subject of cross-examination. The result is that we can only deal with the evidence in the form in which it was laid before the jury, and without the additional facts and reasons which would doubtless have been forthcoming if the witness had been asked to substantiate his figures. This reservation must be borne in mind while examining the analytic results and conclusions.

That the poison is not equally distributed throughout the whole body is shown by the fact that there is considerable difference between the amount found in various organs. Thus the kidneys contained 0.99 gr. per lb., while in the brain, there was only 0.64 gr. per lb. In muscular tissue, such, for example,

as the muscles of the calf of the leg, there would probably have been a much less proportion; while presumably in the bones the proportion would have been exceedingly small. The figure given, viz., 75.8 grs., is just ten times the amount found in the stomach, intestines, liver, kidneys, and brain, viz., 7.58 grs. If this is the basis of the calculation, no cognisance could have been taken of the weight of the whole body, and yet that is one of the factors in the calculation expressly mentioned in his evidence by Dr. Willcox. The witness further estimated that during the period which elapsed between the taking of the dose and death, at least half the total poison would have been eliminated from the body, and therefore multiplied this figure 75.8 by 2, from which he concluded that the amount of veronal taken must have been at least 150 grs. As against this question of weight, the chauffeur, Wilmore, who had carried the deceased upstairs, in reply to a juror, stated that he was "7 st. 8 lbs. in weight, at a rough estimate." When in reply to an unexpected question, a man gives a rough estimate of weight in lbs. as well as stones, there is a strong probability that he has been accustomed to judging weights somewhat accurately. The presumption is that Wilmore's figure is substantially correct. This is further corroborated by the statement made by Roe that on Trevanion's return to England in 1912 "he was weighed on the scale at Victoria Station and weighed 9 st. 3 lbs. when dressed. He had gained 10 lbs. while he was away." One can only guess at the weight of a suit of clothes at any particular time, but assuming it to be 10 lbs., Trevanion's weight at that time must have been 119 lbs., and before he had gained 10 lbs., it would have been 109 lbs. The chauffeur's estimate was 106 lbs. If the weight of the dose bears any proportion to the weight of the body, and Dr. Willcox puts it—body weight, 150 lbs.; dose, 150 grs.—then according to Roe's and the chauffeur's statements of body weight, the dose in the same proportion, would be from 106 to 119 grs. In view of the subsequent arguments the actual amount of dose was rather a matter of material importance. In a case where, for analytical purposes, the weight of the body is one of the factors to be used in making any calculation, the weight might be ascertained by the analyst by direct weighing at the time of the *post-mortem*. The evidence left no doubt as to the cause of death being an excessive overdose of veronal.

An interesting side-issue raised was that of whether or not the doctor should have used the stomach pump on being called in to attend to the case. The medical attendant, Dr. Baines, was cross-examined very closely by Mr. Muir on this point, among the questions and answers being: Do you suggest it is dangerous in the case of an unconscious person to use a stomach pump? (In this case it was.) Can you indicate any book in which I could find such a statement? (No.) Why dangerous in this case? (Because he was so far gone. He was so insensible.) He lived for 32 hours after that. Do you say that to a man in that condition it was dangerous to administer the

stomach pump? (I do.) And in your view more dangerous than to leave the veronal in the stomach? (The other medical men agreed with me.) Dr. Baines had previously stated that to have put a tube down the deceased's throat would have suffocated him. Dr. Willcox was recalled and examined on this point by Mr. Muir. Under the conditions described by Dr. Baines, Dr. Willcox, personally, would have passed a tube and washed the stomach out. Mr. Muir: Would there be any danger of killing the patient, as suggested by Dr. Baines? (Not if it were done with care, and if the patient was not *in extremis*.) In this case the patient lived for 32 hours afterwards. What would you have done in this case? (I should have passed the tube. I did not see this particular case, but that is what I should do generally.) With all respect to learned counsel, a fallacy underlies these questions. Dr. Baines was asked, in effect, what he ought to have done *then* in the light of knowledge only available *since*.

As to book authority, the subject of veronal poisoning is dealt with in Taylor's "Medical Jurisprudence," Sixth Edition. On p. 616 it is related that veronal had been prescribed in 15 gr. doses, which amount the patient had gradually increased until "taking indiscriminately thirty to sixty grains at a time." On one occasion the patient had taken 100 grs. of veronal with suicidal intent, and recovered in three days. On June 29th, 1909, the patient took a dose of veronal which was estimated by the doctor to amount to 120 grs. In addition to the veronal, he had also taken 20 grs. of chloral and 40 grs. of ammonium bromide. He went to bed about 12.30 and the doctor was sent for at 9.45 a.m. The patient was then found to be deeply comatose, but could be made to wince by slapping the face—he was unable to swallow, but later could swallow a teaspoonful at a time. Death occurred on July 4th at 6.30 a.m. There is no record or suggestion of the stomach pump having been used in this instance. Of course, there is this difference, that in the case just quoted some nine hours had elapsed before the doctor was called in, whereas probably the time was only about 1½ hours after the taking of the dose when Dr. Baines arrived.

In the case of Trevanion, the doctor is called in about midnight to attend a patient, suffering from an overdose of veronal, *quantity unknown*; two alternatives present themselves to him and he has to decide at once, and on his own responsibility, no other medical man being present.

The first is to use the stomach pump. This would have largely removed the poison, but in the doctor's opinion the result would have been immediate death through suffocation.

The other alternative was to abstain from the use of a stomach pump, strengthen the action of the patient's heart by an injection of strychnine and digitalin, and trust to the patient being able to withstand the effects of the poison and make a recovery as he had done in a previous instance. For the reasons already given the doctor decided to adopt this latter course, as giving the patient a better chance of life.

The point of the matter is that the doctor had to form his own judgment and act to the best of his own ability at the moment, and that is all any person, whether doctor or chemist, can do, or can be expected to do, in times of emergency.

The proceedings were practically brought to a close by a strongly worded recommendation that veronal and similar drugs should be placed upon the poison schedule, and that it should be made illegal to supply any hypnotic drug unless directly prescribed by a medical man. The coroner undertook that this should be conveyed to the proper authorities.

These remarks will convey to the student some idea as to the extreme interest of some of the points raised in a case which will long be remembered for its general interest in forensic chemistry.

FINANCIAL NOTES.

The British Aluminium Company show profits of £194,824 for the past year, a gain of nearly £42,000 over the previous year's trading.

The United Alkali Company have passed their dividend on the Ordinary shares of the last twelve months. The net profit fell from £306,970 to £221,173.

At the recent meeting of Carbic, Ltd., the chairman stated that a dividend equal to 122½% had been earned during the period covered by the accounts. Steps had been taken to deal with the American rights, and negotiations were also in progress for the sale of the Italian, Canadian, and South African rights. The increase in sales in the home trade was quite satisfactory. A new factory would shortly be erected on the Thames, and they hoped to erect one on the Continent in due course.

The chairman of Borax Consolidated, Ltd., reported a successful year at the recent meeting of shareholders. The net profits amounted to £293,609, or about £3,000 less than last year, which was a record year. Twenty thousand pounds was placed to credit of buildings and plant depreciation. Their depreciation reserve stood at £109,000 odd. A final dividend of 1s. 9d. on the deferred ordinary shares, making a total of 13¾% for the year, was agreed to.

At the recent statutory meeting of the Rubber Curing Patents Syndicate, Ltd., it was stated that the Byrne process had worked satisfactorily on a sample case of rubber which had been sent from Malay to this country for examination. The treatment is said to have been completed within three days of tapping. On arrival the chairman stated that it was considered to be equal to first quality crêpe, and contained less than 1% moisture.

At the recent general meeting of the New Transvaal Chemical Co., Ltd., the chairman, in moving the adoption of the report and accounts, said that the net trading profit for the year ending June 30th last was £48,871, as against £60,883 in the previous year. After providing for general expenditure and depreciation there was a balance of £34,496, as compared with £49,105; £5,000 had been placed to reserve, bringing that fund to £30,000, and it was proposed to pay a dividend of 18% on the ordinary shares.

After charging usual depreciation, trustees' and directors' fees, interest on debenture stock, sinking fund, etc., Samuel Courtauld & Co., Ltd., the well-known manufacturers of artificial silk, show profits for the year of £309,005. Fifty per cent. dividend has been paid during the year, leaving £253,048 to be carried forward, against £55,042 brought forward from the preceding year.

NOTES ON CHEMICAL ENGINEERING.

By J. W. HINCHLEY, A.R.S.M., WH.Sc.

CHAPTER I.—Continued.

SIZE-REDUCTION OF SOLID MATERIALS.

THERE are many varieties of the eccentric mill which have doubtful advantage over the simple type. In one, both stones are driven, in another, the lower stone is made convex and the upper concave, the axis of the lower stone being inclined to the axis of the upper stone, the object in most cases being to maintain even wear on the stones. The end-runner mill (Fig. 16), however, is an important modification of the eccentric mill. The lower

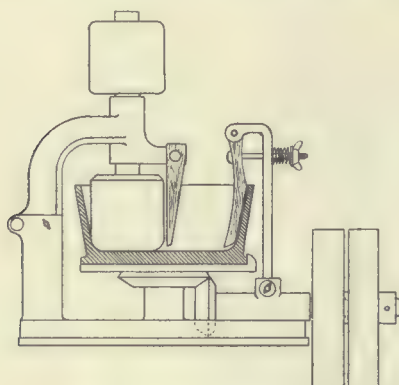


FIG. 16. — END RUNNER MILL.

stone becomes a mortar and the upper is reduced to a pestle or runner of half the diameter of the mortar, giving as large a capacity to the mortar as possible. Only in the smallest size is the runner driven. This mill is extremely valuable for laboratory work and small outputs. In the small sizes the runner is capable of being lifted and the mortar may be removed for emptying. In the larger sizes an emptying slide is provided on the mortar. The mortars and runners are made of wedgwood porcelain, cast iron or granite, and the scrapers which continually bring the material into the grinding are usually of wood. The efficiency of the mill is not high unless fitted with screening arrangements, but its usefulness is great.

For the finest reduction and highest efficiency by grinding the roll mill is to be preferred. In its simplest form, a single roll, usually of granite, revolves against a concave block of the same material which is reciprocated in a direction parallel to the axis of the roll to equalise the wear. When grinding wet an additional roll may be used to feed the grinding roll with material, while a "doctor" or scraper is pressed against its surface to remove the material when ground.

Two-roll machines, similar to Fig. 12, except that the rolls are smooth, are often used for the dry reduction of starch, grain, and soft materials. The surfaces of such grinding rolls must not be polished,

and any polish obtained by wear should be occasionally removed. In the case of steel rolls a sand-blasted surface is excellent, and in stone mills the surface left by a diamond turning tool is equally good.

Three-roll machines have their greatest application in the colour and paint trade. The usual type of machine consists of three equal rolls geared directly together as shown, so that their velocity ratios shall be, for each pair, approximately $2\frac{1}{2} : 1$. The peripheral speed of the fastest roll from which the finished material is removed by a scraper varies from 360 to 600 ft. per minute. The wet material, paint or material in the form of a cream or very soft paste is fed between the middle and lowest speed rolls, which, where a bulk feed is given, are provided with hopper cheeks to hold the material. The rolls are usually pressed together by means of stout spiral or flat springs, and the scraper is held in position by weights.

Another form of this triple roll mill is shown in Fig. 17. In this mill the fastest roll is mounted in fixed bearings and is larger than the other rolls. The feed roll is arranged to slide against the middle roll at an angle of 60 degrees or more, so that a bulk feed can be given.

By careful engineering the power required to do a given amount of work on such mills may be reduced enormously in current practice. Many such mills are costing in power from 20 to 50 % more than necessary, and as a consequence the repairs and renewals accounts are also larger.

In overhauling such mills, oval or badly worn

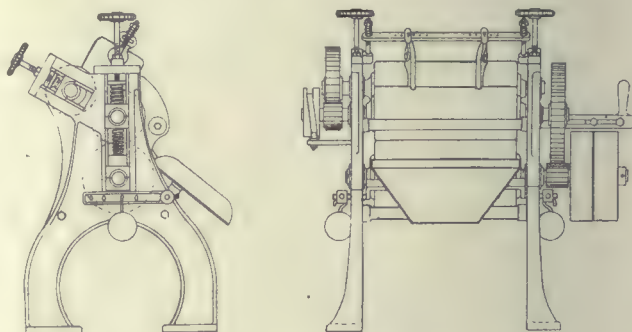


FIG. 17.—TRIPLE ROLL MILL.

spindles should be made true and the grinding surfaces turned true to the spindles by suitable means. Stone rolls are best turned by a diamond, mounted in a suitable holder, at a speed of about 15 ft. per minute with a traverse of about $\frac{5}{16}$ to the inch, water being used as a lubricant. The operation is slow, but needs no close attention except at the end of each cut. Emery wheels, which work faster, are not so satisfactory. Too much care cannot be taken in providing true rolls and mounting them

in good bearings on a stiff frame with good adjustments. A good mill ought not to be allowed to work for more than twelve months without truing up. To equalise the wear on the rolls the middle roll in all types of three-roll mills is reciprocated through a distance of about $\frac{1}{8}$ in. In some mills a simple cam on the roll itself is used to give this movement, but in the best mills a gear-box is provided to give a continually varying reciprocation. The amount of pressure required for the materials treated should be determined and maintained by strict rule. Such pressures vary from 12 to 30 lbs.

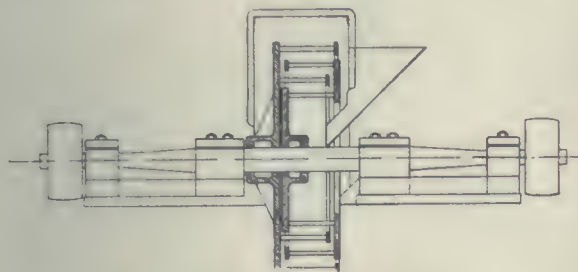


FIG. 18.—"CARR'S" DISINTEGRATOR.

per in. of width of roll. With pasty materials a pressure of 25 lbs. is usually satisfactory, but with paint or similar thin material 15 lbs. per in. is ample. The scraper is generally held by pressure against the revolving roll, at an inclination of about 75 degrees to the radius of the roll at the point of contact.

The scraper may be ground automatically in an emery wheel machine, and if in good order and fitted truly and flat to its support, needs very little pressure to remove the ground material. A badly fitted scraper will not "take off" under any reasonable pressure, so it is best to fix the pressure and thus detect bad scraper adjustments. A pressure of 1 lb. per in. of width of roll is common practice.

The simple way of gearing the rolls together in pairs by means of one cog wheel on each, gives considerable trouble when wear has taken place by the teeth "bottoming" and preventing efficient grinding. New gears of different pitch must be fitted in pairs to obtain the adjustment required. High-class mills are now fitted with additional gear wheels mounted on quadrants, so that the wear of rolls does not affect the adjustment of the gearing. In all such mills involute teeth should be used; cut gears are expensive but are most economical, machine moulded teeth are good, but wheels cast from wooden patterns are hopelessly bad and extremely noisy.

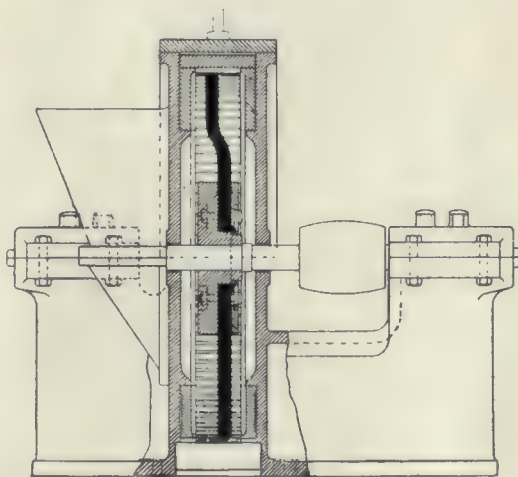
The power required for three-roll mills in good adjustment may be estimated as $1\frac{1}{2}$ h.p. per foot of width of mill with a maximum surface speed of 400 ft. per minute. With badly adjusted mills and with sticky material the power required may be twice this amount.

Disintegrating Machines.—Size - reduction machines which act by disintegration or by blows on the unsupported particles are limited to a few

types. Such machines, designed originally for use in the flour industry, can be used for all materials which break up easily and which are neither hard nor gritty. Limestone, quartz and materials which contain much moisture are quite unsuitable for treatment.

A well-known type is "Carr's" disintegrator (Fig. 18), which consists of several oppositely revolving cages, the bars of which, by successive impacts, beat the material to powder. The fineness increases with the peripheral speed, which in the case of the outer beaters is usually 7,200 ft. per minute. On degreased bones such machines will treat 1 ton per h.p.-hour, while with coal 4 to 5 ton per h.p.-hour may be expected.

A very simple type of disintegrator is "Carter's," (Fig. 19), which consists of a circular chamber lined with chilled cast-iron plates and provided with circular screens, in which a disc carrying from two to six beaters rapidly revolves. The chilled iron plates have grooved or ratched surfaces and the screens usually consist of triangular bars held at a suitable distance apart in a cast-iron frame. The width of the spaces between these bars determines the relative size of the discharged material, but is very much greater. The speed of the tips of the beaters varies in practice from 15,000 to 20,000 ft. per minute, while the outputs depend on the character of the material and the fineness required. A rough approximation to the output may be taken



F.G. 19.—"CARTER'S" DISINTEGRATOR.

to be $2\frac{1}{2} D^3$ cwt. per hour of soft material, D being the diameter across the beaters in feet.

The most economical way of working such machines is to use coarse screens and to sift or dress the product, returning the coarse material to the machine again. A few experiments will generally determine the best practice, and it is often possible to increase the output 50% by this means. The beaters act as fan blades, and drive a considerable amount of air through the machine facilitating the work of screening and at the same time cooling and drying the material.

A defect of the type of machine is that with some

materials much heat is developed, and on this account water-jackets are occasionally fitted.

The machine may be mounted on a dust-tight wooden chamber with or without a hopper base, which receives the disintegrated material and is provided with a trunk for the discharge of the dust-laden air into a suitable dust chamber or dust balloon. The dust chamber is usually a framework of timber carrying screening cloth through which the air passes leaving the dust behind.

Dust balloons are also made of porous material

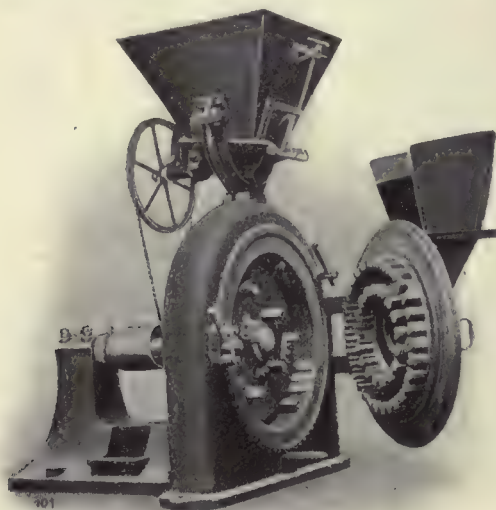


FIG. 20.—“PERPLEX” DISINTEGRATOR.

and discharge their accumulated dust by means of a valve fitted to a spout at its base.

Another excellent disintegrator is the “Perplex” (Fig. 20). This machine is provided with a double set of beaters mounted on the face of a disc which protects the bearing from the disintegrating chamber. A double set of screens and a discharge screen surrounds the whole. Owing to the excellent screening arrangements provided in the construction of the mill itself, a very even-sized product is obtained, which, except for special market requirements, does not require dressing.

(To be continued.)

FARADAY SOCIETY.

THE conference on “Viscosity in Colloidal Solutions,” held at Burlington House, on March 12th last, was a great success. In the absence of the President and Vice-President, the chair was taken by Mr. Emil Hatschek. Professors Ostwald, Freundlich, Henri, and Dr. Pauli all attended, and the meeting attracted a large audience of English chemists. Owing to its interesting character, the importance of the papers contributed, and the discussion which followed, those instrumental in arranging the meeting are to be congratulated on the success of the same, which should give a distinct impetus to the study of this important subject, which has such a direct bearing on both pure and applied chemistry.

ENGINEERING NOTES.

By ROLAND J. DUNDERDALE, B.A. (CAMB.), A.M.I.C.E.

Methods of Storing Coal.

AT the present day when so much is heard about liquid fuel on the one hand, and large hydro-electric power plants—abroad—on the other, it is as well to bear in mind that in this country at any rate, for a considerable time to come coal will, as at present, constitute almost the entire source of our power.

This being unquestionably the case, it is surprising how little thought appears to be devoted to its storage, not merely by purely engineering works, but also by chemical ones, where, it might be assumed, a better appreciation of the losses due to fire and, still more, to constant depreciation of the coal would exist.

Probably the larger proportion of chemical works in this country burn over 100 tons of slack a week at least; slack is mostly bituminous, and it will at once be seen that should there be a deterioration of 5% of inflammable volatile matter, about £130 is lost annually in this way.

This sum ought easily to cover the interest on careful wet or other storage, and the wages of handling, as far as there is extra handling with any particular storing process, and leave a margin of what is virtually clear profit.

Driving Chemical Factories.

The drive in chemical factories often presents several factors exceedingly difficult to reconcile.

To take only one instance—pumping, or group driving a set of small machines. In both cases, a suitable size of motor seems to be exactly what is required, but the consequences of sparking may be so terrible or costly in some chemical factories, that even a specially low tension motor drive is discarded in case of accidents.

Probably—especially in the case of pumps—the old-fashioned local steam set is the best available alternative.

Compressed air is often suggested, but except for one particular case—mine locomotives—is quite unsuitable. It is true that dry compressed air can be transmitted a good distance and act very effectively, especially if expanded in two stages with heating between the stages—but against this must be reckoned a costly compressing set, cooling, drying arrangements, and pipe lines which may easily leak away large sums of money before ever they are found out; a greatly increased first cost of the air motors over steam—and the fact that if the air comes to them damp, or cannot get heat between the stages of expansion, there is a plentiful crop of ice, and a fairly quick and certain stoppage of the machine.

Large Scale Pumping.

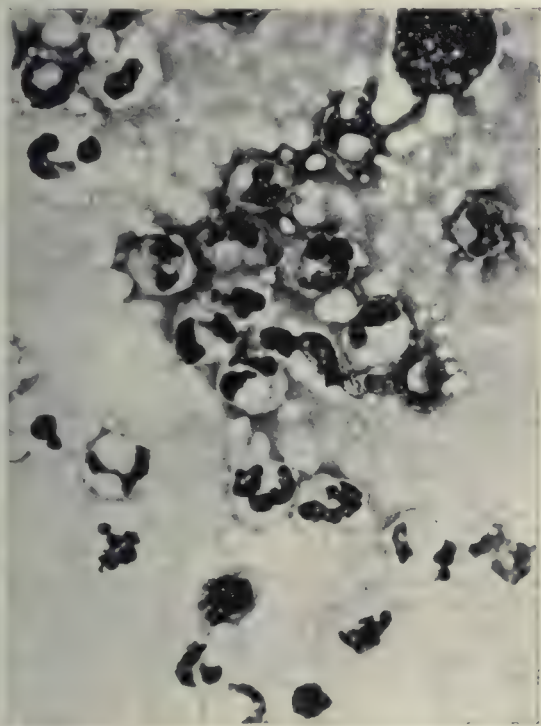
By contrast with the above, it is very often desired to pump large volumes of non-inflammable liquors; and even in cases where they are not viscous, this often presents a costly and difficult problem. The Humphrey pump now working so successfully at Chingford and other places, must have struck many people as filling a long-felt want.

Its simplicity at the “explosion end” and total absence of valves at the “water end,” render it unusually suitable for a great many purposes which before caused a constant expense in renewals and stoppages.

REVIEWS OF BOOKS.

"FATTY FOODS; THEIR PRACTICAL EXAMINATION." By E. R. Bolton and Cecil Revis. J. and A. CHURCHILL, London, 1913. Pages 371 + v, including 2 Indexes and 5 Appendices. Chapters IX., with 36 Figures and 6 Plates. Price 10/0 net.

THIS work bears the stamp of the laboratory on every page, as might be expected. The different chapters deal with the recognised analytical methods which are in use at the present time, the examination of fatty foods being regarded from the edible standpoint. Beef fat, lard, butter, margarine and



CELLULAR ELEMENTS IN MILK SEDIMENT. ($\times 1,000$).

vegetable oils and fats are considered in satisfactory detail, and sections are devoted to cocoa and chocolate, feeding stuffs and milk. The effect of the modern treatment of oils with hydrogen in the presence of a catalyst is noted, and its disturbing action on certain tests pointed out. This work will be welcomed by those who have to deal with the subject. The book is well illustrated and contains a great deal of useful data which, in practically all cases, has been checked in detail by the authors. The accompanying illustration is typical of the care which has been taken over the preparation of this volume.

"THE TECHNOLOGY OF IRON ENAMELLING AND TINNING." By Julius Grünwald. CHARLES GRIFFIN & CO., LTD., London, 1912. Pages 138 + vi, including Index. Chapters XVI. Price 6/- net.

This is a translation of a series of papers dealing

with different problems connected with the iron enamelling and tinning industries. These are dealt with in one volume as most manufacturers deal with both operations. The subject-matter comprises such widely different subjects as the economic significance of the sheet-iron enamelling industry and, say, the theory and technology of Purple of Cassius. A certain want of continuity in the subjects dealt with is inevitable. On the other hand, the work undoubtedly contains much useful information, and deals with many points which an ordinary textbook could hardly cover. The book is well translated, and will attract the attention of those who are engaged in the manufacture of this ever-widening industry.

"SCIENTIFIC METHOD; ITS PHILOSOPHY AND ITS PRACTICE." By F. W. Westaway. BLACKIE & SON, LTD., London, 1912. Pages 439 + x, including Appendix and Index. Divided into four sections, Chapters XLII. Price 6/-.

This work will be welcomed by all those who are interested in the general development of scientific thought and practice. The modern methods adopted by science differ materially from those of Aristotle, or even Bacon. The progressive nature of the development in scientific method is insisted upon, and just as we to-day smile at the methods of Descartes, "who, himself, found serious fault with the methods of the ancients," there is little doubt but that the methods of to-day will be subject to material revision at some future time.

This work is written without bias, except that the author crosses swords with the humanists, the representatives of classical scholarship. At the same time he points out that the realists, who represent natural science, agree in thinking with the former, "that they have discovered the means for creating the ideal citizen, and yet the ideal citizen does not seem to appear." He quotes Macaulay as defining a scholar as "a man who can read both Greek and Latin with his feet on the hob," and contends that in many quarters the opinion is held that a more satisfactory realisation of humanism is to be obtained by contact with the ancient classics than by contact with humanity itself. The average realist does not, however, escape criticism in his complaint of the "shocking ignorance" of the humanist over the commonplace of natural phenomena. The author rightly demands that in the interest of future progress a truce shall be called between these rival schools, and that the best of both methods shall be incorporated in future educational progress.

We are in thorough agreement with the author's views on research, and with the statement that when this is undertaken in the undergraduate stage, that it leads "to a quite remarkable improvement in judgment, independence of thought, and maturity,

as produced by a year's research," and that research develops qualities which are apt to atrophy when the student prepares for examination. Also that successful research implies a mastery of what is meant by the scientific method.

The writer also insists that those who wish to master the scientific method must follow the history of science, and observe how one faulty method has been superseded by another, and fully realise how difficult it has been to discover the principles of the true method. The advice concerning hasty generalisations, and the warning against the possible influence of a pet hypothesis, and the possibility of the same masquerading as fact, is sound in every respect—"hypotheses are cradle-songs which lull the unwary to sleep." It is still not so fully recognised as it should be that the student must acquire a knowledge of the laws of inductive reasoning, and learn to balance probabilities.

All this, and a great deal more, is excellent, and forms a satisfactory introduction to the book itself, which should not only be in the hands of every student, but be made the subject of careful and thorough study. It will act as a corrective to "the effect of constantly hearing one point of view to the exclusion of all others."

The book is divided into four sections. The first one deals with the philosophy of scientific method, and at some length with philosophy and its sub-divisions, and then with the teaching of different schools from the time of the Sophists, through that of Plato, Aristotle, Bacon, Descartes, Locke, and Hume, to that of Mill, Bain, Herbert Spencer and the other moderns. The second section deals with the logic of scientific method, and discusses general investigation and experiment, Mill's canons, types of classification, analysis of phenomena, generalisation, and empirical laws, hypotheses, measurement, and error and its correction. This section will appeal more especially to the chemical student. The third section is devoted to an account of famous men of science and their methods, and here, perhaps, some exception may be taken to the bald descriptions of the work of what are classed as "other investigators," in which in some cases two lines are considered sufficient to describe their life's work.

The fourth section may be said to deal with modern method in scientific teaching. It is entitled "Some Elementary Principles of Science Teaching." The Heuristic method and Professor Armstrong's advocacy of the same is discussed. The function of the teacher is said to guide not to tell; "he should never help a boy over a stile until the boy has had at least one good try to get over himself." One important factor in the Heuristic method is the presence of a very competent teacher. "In the hands of an unskilled teacher the method is almost certain to result in disaster." The final words of warning to the young teacher are characteristic: "a prepared syllabus is, for a teacher, an educational snare. No teacher worth his salt would ever dream of using a syllabus prepared by another person."

To the teacher or student who has not considered this side of his work in any detail, the book will open out a new world of ideas. No worker in science can fail to appreciate its value in this respect, and the author is to be entirely congratulated on the success of his venture, and the method adopted to bring a difficult subject before the average reader.

BOOKS RECEIVED.

"Organic Chemistry; Including Certain Portions of Physical Chemistry," by Howard D. Haskins. Chapman & Hall, Ltd., London, 1913. Pages 430 + xiii, including Appendix and Index. Chapters XXXII., with 25 Illustrations. Price 8/6 net.

"Introduction to the Rarer Elements," by Philip E. Browning. Chapman & Hall, Ltd., London, 1912. Pages 232 + vii, including Index. Chapters XIV., with a Frontispiece. Price 6/6 net.

"An Introduction to the Physics and Chemistry of Colloids," by Emil Hatschek. J. & A. Churchill, London, 1913. Pages 94 + ix, including Indexes. Chapters X., with 14 Illustrations. Price 2/6 net.

"The Chemical Constitution of the Proteins," by R. H. A. Plimmer. Part II. Longmans, Green & Co., Ltd., London, 1913. Pages 107 + xii, including Bibliography and Index. Price 3/6 net.

"The Mineralogy of the Rarer Metals," by E. Cahen and W. O. Wooten. Charles Griffin & Co., Ltd., London, 1912. Pages 211 + xiv, including Index. Price 6/- net.

"Sulphuric Acid and Alkali," by George Lunge. Fourth Edition. Vol. I., Parts I., II., III. Gurney & Jackson, London, 1913. Pages 1617 + xii, including Addenda and Indexes. Chapters XIV., with 543 illustrations. Price 63/- net.

"The Elements of Chemical Engineering," by J. Grossman. Second Edition. Charles Griffin & Co., Ltd., London, 1913. Pages 152 + viii, including Index. Chapters XI., with 50 Illustrations. Price 3/6 net.

"A Foundation Course on Chemistry for Students of Agriculture and Technology," by J. W. Dodgson and J. Alan Murray. Longmans, Green & Co., Ltd., London, 1913. Pages 243 + x, including Appendix and Index. Chapters XVI., with Diagrams. Price 3/6 net.

"Qualitative Determination of Organic Compounds," by J. W. Shepherd. W. B. Clive, London, 1913. Pages 348 + xvi, including Appendices and Index. Chapters XVII., with 21 Illustrations. Price 6/6.

"Ancient and Modern Views Regarding the Chemical Elements," by Sir William Ramsay. Smithsonian Institution, Washington, U.S.A., 1912. Pages 15.

"What Electrochemistry is Accomplishing," by Joseph W. Richards. Smithsonian Institution, Washington, U.S.A., 1912. Pages 16.

"The Production and Identification of Artificial Precious Stones," by Noël Heaton. Smithsonian Institution, Washington, U.S.A., 1912. Pages 24, including 3 Plates.

"Mine Fires and How to Fight Them," by James W. Paul. Miners' Circular 10, Bureau of Mines, Washington, U.S.A., 1912. Pages 14.

"Accidents from Falls of Roof and Coal," by George S. Rice. Miners' Circular 9, Bureau of Mines, Washington, U.S.A., 1912. Pages 15.

"Metallic Alloys; Their Structure and Constitution," by G. H. Gulliver. Second Edition. Charles Griffin & Co., Ltd., London, 1913. Pages 409 + vi, including Index. Chapters XI., with 310 Illustrations. Price 10/6 net.

NEW METHODS OF ANALYSIS.

METHODS FOR THE DETERMINATION OF WATER IN PETROLEUM AND ITS PRODUCTS.¹

By IRVING C. ALLEN and WALTER A. JACOBS.

THIS paper is issued by the Bureau of Mines in response to numerous inquiries regarding methods for the determination of water in fuel oils and in petroleum products, and is part of a report on petroleum technology. This report, issued chapter by chapter, aims to describe how petroleum products can be improved in quality, how they can be more efficiently utilised, and how some materials now regarded as waste products can be made useful.

The Water Content of Oil.—Water in a lubricating oil sometimes forms emulsions that tend to lower the durability of the oil and make it less efficient as a lubricant. In fuel oils the unfavourable effect of water is even greater. A fuel oil containing considerable water when burned under a steam boiler gives an unsteady flame that tends to go out. Water, being non-combustible, reduces the heating value of an oil in direct ratio to the percentage present, and converted into steam increases the inert and valueless gases within the firebox, reducing the heating effect of the combustible gases that should normally occupy the firebox space.

A fuel oil containing water when burned in an internal combustion engine will be even more unsatisfactory. A drop of water may prevent ignition of the fuel, and a number of such failures of the fuel to ignite would stop the engine.

The importance therefore of accurately determining the water content of an oil before use is recognised. Various methods for the determination of water are therefore now described.

CLASSIFICATION OF METHODS FOR THE DETERMINATION OF WATER.

Methods employed for the determination of water in petroleum and its products may be classified as follows:—

1. Ascertaining the loss of weight by heating.
2. Diluting with a solvent and separating by gravity.
3. Diluting with a solvent and separating with a centrifuge.
4. Treating with calcium carbide.
5. Treating with sodium.
6. Use of a colour-comparator tube.
7. Treating with normal acids.
8. Electrical treatment.
9. Distilling with a nonmiscible liquid.
10. Directly distilling off the water.

In this report the above-mentioned methods for the determination of water in petroleum and in its products are taken up in order, a discussion of each, and conclusions as to its value are given, and a bibliography bearing on the general subject is presented.

1. Ascertaining the Loss of Weight by Heating.

Conradson² determines the water content of heavy oils

by the loss in weight on heating. However, he recognises the fact that whenever a heavy oil is heated to a temperature of 100° C. some oil is volatilised and lost.

Wright³ heats to from 105° C., Hurst⁴ to 220° F. and Archbutt and Deeley⁵ to from 105° to 110° C.; Davis⁶ saturates a tarred filter paper and heats to 110° C.; Patrick⁷ heats the oil until slight decomposition takes place and assumes the loss in weight to be a loss of water.

Gavalovski⁸ has improved the evaporation method by using duplicate samples in tarred flasks. He leaves one flask open in the usual manner and attaches to the other a sulphuric-acid drying tube, which, he states, absorbs the water and allows the oil vapours to pass through unabsorbed. The difference in loss of weight on heating, he assumes to be a water loss. Lowenstein⁹ dilutes with 95% alcohol and dries repeatedly on a water bath and then at a temperature of 105° C. to constant weight.

The evaporation method, varied as described above, is approximate and applicable only to heavy oils and greases. Its accuracy even with heavy greases is questionable.

2. Diluting with a Solvent and Separating by Gravity.

Curtis and Thompkins¹⁰ dilute 200 c.c. of the oil with 600 c.c. of gasoline (specific gravity, 0.7000), allow the liquid to settle in a graduated glass tube, and read the volume of water settling to the bottom of the tube. Sussanow¹¹ in using this method employs benzene instead of gasoline as a solvent.

This method is only approximate. Its accuracy is modified by the quantity and quality of the diluent used, by the amount of mineral matter in the oil, by the character of the insoluble portions of the oil itself, such as asphaltine, and by the length of time allowed for settling.

3. Diluting with a Solvent and Separating with a Centrifuge.

Charitschkoff,¹² Wieleczynski,¹³ Rosenthal,¹⁴ and O'Neill¹⁵ have greatly improved the method described under 2. After diluting the oil with an equal volume of benzene they whirl it vigorously until the separated layer of water does

³ Wright, A. C., "Analysis of Oils and Allied Substances," p. 104, 1903; *Four. Ind. and Eng. Chem.*, Vol. I., June, 1909, p. 355.

⁴ Hurst, G. H., "Determination of Water in Greases," *Four. Ind. and Eng. Chem.*, Vol. I., p. 355, June, 1909.

⁵ Archbutt, L., and Deeley, R. M., "Lubrication and Lubricants," pp. 293-4, 1900; *Four. Ind. and Eng. Chem.*, Vol. I., p. 355, June, 1909.

⁶ Davis, C. B., "Elimination and Determination of Water in Oils, Fats, and Waxes," *Four. Am. Chem. Soc.*, Vol. XXIII., pp. 487-8, 1901; *Four. Soc. Chem. Ind.*, Vol. XX., p. 941, September 30th, 1901.

⁷ Patrick, G. E., "Apparatus for Rapid Determination of Water in Butter," *Four. Am. Chem. Soc.*, Vol. XXVIII., pp. 1611-16, 1906; *Chem. Zeit.*, Vol. XXXII., p. 1176, 1908; *Chem. Abs.*, Vol. I., p. 70, 1907, Vol. III., p. 504, 1909.

⁸ Gavalovski, A., "Crude Oil and Water," *Österr. chem. tech. Zeit.*, Vol. XXVII., p. 3; *Chem. Abs.*, Vol. III., p. 1078, May 10th, 1909.

⁹ Lowenstein, A., "The Rapid Determination of Moisture in Commercial Products of a Viscous or Semi-solid Consistency," *Four. Ind. and Eng. Chem.*, Vol. I., p. 252-3, 1909; *Chem. Abs.*, Vol. III., p. 1971, September 10th, 1909.

¹⁰ Curtis, M., and Thompkins, P. W., "Notes on the Determination of Water in California Crude Oils," *Four. Soc. Chem. Ind.*, Vol. XXI., p. 1519, December 31st, 1902.

¹¹ Sussanow, J., "ber die Defekte der Benzinmethode der Wasserbestimmung im Erdöl," *Neft. Djelo.*, No. 8, pp. 7-10, 1910.

¹² Charitschkoff, K. W., "Bestimmung von suspendierten Wasser in dem Naphtha," *Chem. Zeit.*, Vol. XXX., p. 93, 1906; *Westnik Shiroff* *veschnich*, Vol. I., p. 187, 1905.

¹³ Wieleczynski, M., "Wasserbestimmung in Rohöl," *Petroleum*, Vol. III., p. 285, 1907.

¹⁴ Rosenthal, von, "Über die Wasser- und Schmandbestimmung in Erdölen," *Chem. Zeit.*, Vol. XXXIII., p. 1259, 1909; *Petroleum*, Vol. VI., p. 22, 1909.

¹⁵ O'Neill, Edmund, "The Determination of Water and Asphaltine in Petroleum," *Cal. Derrick*, Vol. III., p. 3, June, 1910, p. 5, December, 1910; *Petroleum* Vol. VI., pp. 777-8, April, 1911, Vol. V., p. 1393, August, 1910.

¹ Published by the "Bureau of Mines," Washington, U.S.A.

² Conradson, F. P., "Determination of Water in Greases," *Four. Am. Chem. Soc.*, Vol. XXVI., p. 705, June, 1904; *Four. Ind. and Eng. Chem.*, Vol. I., p. 355, June, 1909.

not appear to increase in volume. However, as water is somewhat soluble in any diluent used and also in oils, a portion of the water content will fail to appear, consequently the method in which a diluent is used cannot be considered accurate. It is advisable first to agitate the diluent vigorously with water and then to separate with the centrifuge in order to saturate it with water before using.

Groschuff¹⁶ states that 100 gms. of benzene will dissolve 0.03 gm. of water at 3° C. and 0.337 gm. of water at 77° C.; whereas petroleum products (density 0.792) will dissolve from 0.0012 gm. at 2° C. to 0.097 gm. at 94° C.

4. Treating with Calcium Carbide.

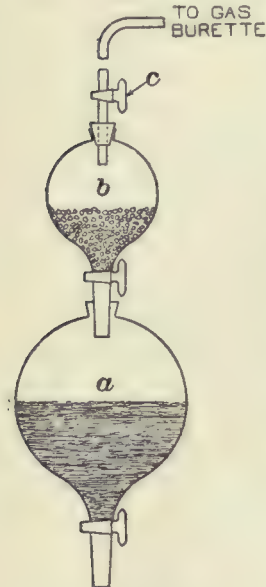


FIG. 1.

Dupré,¹⁷ Danne,¹⁸ O. Masson¹⁹ and I. Masson²⁰ agitate samples of the various materials containing water under examination with an excess of calcium carbide, measure the volume of acetylene evolved, and calculate the content of water.

Wielecynski²¹ and Roberts and Fraser²² maintain that this method may be applied successfully to petroleum. The method may be carried out conveniently as follows:—

To the stopper of a 250-c.c. separatory funnel such as *a*, Fig. 1, is fitted a second 100-c.c. separatory funnel *b*, which in turn is fitted with a small glass stopcock *c*.

17.24 gms. of the sample is run into *a*, the cock of *b* is closed, and *b* is connected to *a*. About 10 gms. of powdered calcium carbide is run into *b* and cock *c* inserted. The cock of *b* is cautiously opened, the dropping of any carbide into *a* being avoided, and the whole is immersed in a water bath maintained at any convenient temperature *t*. Immersion is made up to cock *c*, which is open to the atmosphere. When the temperature *t* has been reached, *c* is closed, the apparatus is removed from the bath, and the carbide is shaken into *a*. The sample and carbide are then shaken vigorously and, if necessary, are cooled several times under cold water. After the reaction is completed, the whole is again brought to temperature *t* by immersion in the water bath, connection is made between *c* and a gas burette, and

the increase in volume due to the generation of acetylene is measured. One gram of water generates approximately 580 c.c. of acetylene²³ at 0° C. and 760 mm. pressure.

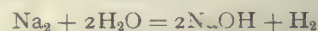
It should be noted that acetylene is soluble in oils. One c.c. of kerosene (specific gravity 0.7950) will dissolve approximately 1.375 c.c. of acetylene, and 1 c.c. of spindle oil of specific gravity 0.8667 will dissolve approximately 0.95 c.c. of acetylene; that is, an average of 1.10 c.c. of acetylene per 1 c.c. of oil. This absorption is not a constant but varies with different oils. This variation will introduce an error of approximately 110 c.c. per 100 c.c. of oil used, or 17.24 gms. of a sample will absorb 18.96 c.c. of acetylene introducing an error of approximately 18.96 in 580 c.c., that is, 3.2% in the water content. For this error approximate correction can, of course, be made. If the sample is too viscous to mix readily with the carbide, it may be diluted with 50 c.c. of an oil of low vapour tension such as kerosene, but correction must be made for the acetylene absorbed therein. For example, 55 c.c. of acetylene absorbed in 50 c.c. of the diluent plus 18.96 c.c. absorbed in the 17.24 c.c. of a sample will give an approximate correction of 74 c.c., which is to be added to the burette reading. It must also be noted that a portion of the water is held by the calcium hydroxide formed in the action of the water on the carbide.

This method is easily carried out, is approximately correct, and may be used for many classes of materials containing water.

5. Treating with Sodium.

Graefe²⁴ estimates the water content of an oil by agitating with finely cut metallic sodium. This process may be carried out as follows:—

For each gram of water in the sample of oil, about 2 gms. of finely cut sodium is used in the same apparatus and in exactly the same manner as described in method 4. The reaction will be as follows:—



or 1 gm. of water will generate $\frac{3}{8}$ gm. of hydrogen.

One thousand cubic centimeters of hydrogen weighs 0.09004 gm.²⁵ at 0° C. and 760 mm. pressure, or 1 gm. of hydrogen has a volume of 11,106.17 c.c. One gram of water generates $\frac{3}{8}$ (11,106.17) c.c., or 617.0095 c.c. of hydrogen; or 1 c.c. of hydrogen represents 0.00162 gm. of water in the sample used.

This method gives much more accurate results than the use of calcium carbide, as hydrogen is not appreciably soluble in petroleum products.

6. Use of a Colour-Comparator Tube.

Martin²⁶ compares the sample under consideration in a colour-comparator tube with standard mixtures of oil and water. This method of determination of water content is roughly approximate and applicable only when the water is present in visible suspension.

¹⁶ Groschuff, E., "The Solubility of Water in Benzene, Petroleum, and Paraffin Oil," *Chem. Abs.*, Vol. V., p. 2550, August 10th, 1911.

¹⁷ Dupré, P. V., "Determination of Water in Cordite by means of Calcium Carbide," *Analyst*, Vol. XXXI., p. 213, 1905.

¹⁸ Danne, H. A., "The Estimation of Water in Organic Matter by means of Calcium Carbide," address before the Society of Chemical Industry of Victoria in 1911.

¹⁹ Masson, O., "Determination of Moisture in Sheep's Wool by Action of Calcium Carbide," *Proc. Soc. Chem. Ind.*, Victoria, 1909.

²⁰ Masson, I., "The Use of Calcium Carbide for Determining Moisture," *Chem. News*, Vol. CIII., pp. 37—8, 1911; *Chem. Abs.*, Vol. V., p. 1377, April 20th, 1911; "Determination of Water of Crystallisation by Action of Calcium Carbide," *Trans. Chem. Soc.*, Vol. XCVII., pp. 851—67, 1910.

²¹ Wielecynski, M., "Determining Impurities (Water) in Boryslaw (Galicia) Petroleum," *Naphtha*, Vol. XII., pp. 23—5, 1904; *Four. Soc. Chem. Ind.*, Vol. XXIII., p. 504, May 16th, 1904.

²² Roberts, R. W., and Fraser, A., "Easy Process for Estimating Water in Petroleum," *Four. Soc. Chem. Ind.*, Vol. XXIX., pp. 197—8, 1910; *Chem. Abs.*, Vol. IV., p. 1664, June 20th, 1910; *Petroleum*, Vol. V., p. 1173, July 6th, 1910, Vol. VI., p. 2245, September 6th, 1911; *Matieres Grasses*, p. 4, 1911; *Met. and Chem. Eng.*, Vol. VIII., p. 283, May, 1910.

²³ Masson, I., "Determination of Water of Crystallisation by Action of Calcium Carbide," *Trans. Chem. Soc.*, Vol. XCVII., pp. 851—67, 1910; "The Use of Calcium Carbide for Determining Moisture," *Chem. News*, Vol. CIII., pp. 37—8; *Chem. Abs.*, Vol. V., p. 1377, April 20th, 1911. Roberts, R. W., and Fraser, A., "Easy Process for Estimating Water in Petroleum," *Four. Soc. Chem. Ind.*, Vol. XXIX., pp. 197—8, 1910; *Chem. Abs.*, Vol. IV., p. 1664, June 20th, 1910; *Petroleum*, Vol. V., p. 1173, July 6th, 1910, Vol. VI., p. 2245, September 6th, 1911; *Matieres Grasses*, p. 4, 1911; *Met. and Chem. Eng.*, Vol. VIII., p. 283, May, 1910.

²⁴ Graefe, E., "Zur Wasserbestimmung in Rohpetroleum," *Petroleum*, Vol. I., pp. 813—17, 1906; *Four. Soc. Chem. Ind.*, Vol. XXV., p. 1035, November 15th, 1906.

²⁵ Landolt and Börnstein, "Physikalisch-chemische Tabellen," p. 223, 1905.

²⁶ Martin, W. H., "Estimation of the Quantity of Oil contained in Feed Water," British Patent, 11,067, December 6th, 1905.

7. Treating with Normal Acids.

Nettel²⁷ mixes 100 c.c. of the sample with 100 c.c. of petroleum spirit, adds 50 c.c. of decinormal hydrochloric acid, agitates five minutes, allows the mixture to settle at 65° C. for half an hour, and titrates an aliquot part of the separated acid-water layer with normal alkalis. He concludes that the loss in acidity of the standard solution is due to the absorption of acid by the water dissolved in the oil, basing his conclusions on the assumption, first, that water in petroleum is neither acid nor alkaline; second, that the added acid solution mixes thoroughly with the water in the oil; and third, that crude oil itself has no action on the acid.

Crude oil often contains natural mineral waters which may be either acid or alkaline, and refined oils may often contain some of the wash alkalies. The presence of such mineral waters or wash alkalies would prevent accurate results from the use of the method described above.

8. Electrical Treatment.

A convenient method to reduce the water content of an emulsified oil to approximately 0.5 of 1% has been developed by Cottrell and Speed,²⁸ Cottrell and Wright,²⁹ and Cottrell,³⁰ and is described by Beazley.³¹ The method is admirably adapted for reducing the water content on a large scale. A convenient laboratory apparatus may be made as follows:—

A glass tube about 5 cm. in diameter and 30 cm. long, and open at the top, is drawn out at its lower end and fitted with a glass cock. On the inner surface of the tube is fitted a copper-gauze cylinder (*c*, Fig. 2) extending from the top to within 5 cm. of the bottom. Between the gauze and the tube is placed a single wrapping of wet cheesecloth or very thin muslin. The tube, held in a vertical position, has centered within it a heavy copper wire or rod, *r*, which also extends from the top to within 5 cm. of the bottom. The copper wire and the copper-gauze cylinder are connected to the high-potential (2,200-volt) terminals of a step-up transformer, *t*.

In use the tube is filled with the emulsified oil to be examined, and the circuit is closed. The high-tension current breaks down the emulsion and allows the water to trickle down the cheesecloth and settle into the lower end of the tube where it can be drawn off. With oils containing considerable water, the current must be broken at short intervals to prevent overheating of the oil.

This process will readily reduce the water content of an emulsion, with little heating, to as low as 0.5 of 1% in half an hour, and is admirably adapted to reducing the water content of emulsions when heating is objectionable, but quantitatively it is far less accurate than methods 2, 3, 4, 5, 9, and 10.

²⁷ Nettel, R., "Determination of Water in Petroleum," *Chem. Zeit.*, Vol. XXVIII., p. 867, 1904; *Jour. Soc. Chem. Ind.*, Vol. XXIII., p. 952, 1904.

²⁸ Cottrell, F. G., and Speed, J. B., "Separating Particles of one Liquid, as Water, Suspended in Another," U.S. Patent, 987,114, March 21st, 1911; *Chem. Abs.*, Vol. V., p. 1993, June 10th, 1911. "Separating Mixed Liquids," U.S. Patent, 987,115, March 21st, 1911; *Chem. Abs.*, Vol. V., p. 1993, June 10th, 1911. "Apparatus for Treating Mixed Liquids Electrically to Effect their Separation," U.S. Patent, 987,116, March 21st, 1911; *Chem. Abs.*, Vol. V., p. 1993, June 10th, 1911.

²⁹ Cottrell, F. G., and Wright, A. C., "Separating Mixed Liquids by Electric Treatment," U.S. Patent, 987,117, March 21st, 1911; *Chem. Abs.*, Vol. V., p. 1993, June 10th, 1911.

³⁰ Cottrell, F. G., "Separating one Liquid from Suspension in Another," U.S. Patent, 994,377, June 6th, 1911; *Chem. Abs.*, Vol. V., p. 2534, August 10th, 1911.

³¹ Beazley, A., "Removal of Water from Crude Petroleum," *Oil Age*, Vol. III., pp. 2-4, April 21st, 1911; *Petroleum*, Vol. VI., p. 2075, 1911; *Chem. Abs.*, Vol. V., p. 3727, 1911.

9. Distilling with a Nonmiscible Liquid.

Dean³² estimates the moisture in creosote as a result of distillation with a water-saturated xylene and of measurement of the water that separates in the distillate. Holde³³ and Marcusson³⁴ use the same method for water in greases, whereas Marcusson³⁵ uses toluene, as well as xylene.

Testori³⁶ employs turpentine in a like manner for the determination of the water content of molasses; Prutzman³⁷ uses a mixture of benzene and toluene for this purpose. Sadtler³⁸ recommends the use of benzene boiling at a temperature of 300° to 450° F.

A convenient method is as follows:—

One hundred grams of the sample is mixed in a distilling flask with 200 gms. of toluene (or benzene³⁹ or xylene) and distilled in the usual manner until the distillate comes over perfectly clear. The distillate is allowed to settle by gravity, or is separated by a centrifuge, and the volume of water is read off directly, or the water may be withdrawn with a micropipette and weighed. As water is somewhat soluble in all of the three hydrocarbons mentioned, the method is not accurate but is convenient when only approximate results are desired.

10. Distilling off the Water Directly.

Bell,⁴⁰ Senger,⁴¹ and Allen⁴² distill the sample directly and measure or weigh the quantity of water that settles in the distillate.

The water content may be accurately and conveniently determined during the course of an ordinary distillation in the following manner:—

Two hundred grams of the sample is weighed into a one-fourth-liter-distilling flask and the distillation carried out in the ordinary manner at the rate of one drop of



FIG. 2.

³² Dean, A. L., "Estimation of Moisture in Creosoted Wood," *Forest Service Cir.*, No. 134, 1908; *Jour. Ind. and Eng. Chem.*, Vol. II., p. 66, February, 1910.

³³ Holde, D., "Wasserbestimmung in Fetten," *Petroleum*, Vol. IV., p. 14, 1908; *Zeitschr. angew. Chem.*, Vol. XXXI., pp. 2138-44, 1908; *Chem. Abs.*, Vol. III., p. 123, 1909; *Jour. Ind. and Eng. Chem.*, Vol. I., p. 356, June, 1909.

³⁴ Marcusson, J., "Über die Wasserbestimmung in Ölen, Fetten, und Seifen durch Destillation," *Mitt. K. Material-Prüfungsamt*, Vol. XXIII., p. 58, 1908; *Jour. Ind. and Eng. Chem.*, Vol. II., p. 66, February, 1910.

³⁵ Marcusson, J., "Die Bestimmung des Wasser- und Säuregehaltes von Schmierfetten," *Zeitschr. angew. Chem.*, Vol. XVIII., p. 754, 1905.

³⁶ Testori, G., "Determination of Water in Tars by Distillation," *Stas. sperim. agara. Ital.*, Vol. XXXVII., pp. 366-9; *Chem. Centralbl.*, Vol. LXXV., pp. 562-3, 1904; *Jour. Ind. and Eng. Chem.*, Vol. II., p. 66, February, 1910.

³⁷ Prutzman, P. W., "Distillation Test for Water in Petroleum," *Cal. Derrick*, Vol. III., p. 5, February, 1911; *Petroleum*, Vol. VI., p. 722, April 5th, 1911.

³⁸ Sadtler, S. S., "The Determination of Moisture by Distillation," *Jour. Ind. and Eng. Chem.*, Vol. II., pp. 66-7, February, 1910; *Chem. Abs.*, Vol. IV., p. 1006, April 20th, 1910.

³⁹ Groschuff, E., "The Solubility of Water in Benzene, Petroleum, and Paraffin Oil," *Chem. Abs.*, Vol. V., p. 2550, August 10th, 1911.

⁴⁰ Bell, J. C., "Estimation of Water in Paraffin Residues and Crude Paraffin," *Chem. News*, Vol. XXX., pp. 57-8, 1874.

⁴¹ Senger, E., "Bestimmung des Wassergehaltes im Teer durch Destillation," *Jour. Gasbel.*, Vol. XLV., p. 841, 1902; *Jour. Soc. Chem. Ind.*, Vol. XXI., p. 1475, 1902; *Jour. Ind. and Eng. Chem.*, Vol. II., p. 66, February, 1910.

⁴² Allen, I. C., Jacobs, W. A., and Burrell G. A., "Physical and Chemical Properties of the Petroleum of the San Joaquin Valley, with a Chapter on Analyses of Natural Gas from the Oil Fields of Southern California," *Bulletin* 19, p. 8, Bureau of Mines, 1911.

distillate per second. The distillation can be performed most accurately in an electric still.⁴⁸ At temperatures between 90° and 150° C. the water distills over and can be removed from the receivers by means of a micropipette and weighed. Usually a few drops of water adhere to the condenser and fail to run into the receivers; in this event a small pellet of absorbent cotton, moistened with water, squeezed as dry as possible, and weighed, is fastened to a wire and run up into the condenser to remove these last traces of water. The amount of the increased weight of the cotton pellet, reckoned as water, is added to the weight of the water in the receivers.

With an oil containing considerable water, it is advisable to cause a slow current of a dry, inert gas, such as carbonic acid, to bubble through the oil in the distilling flask to carry off the vapours of oil and water as soon as formed. The gas current will reduce bumping and the overheating of the oil to a minimum. The condenser must also be kept well cooled throughout the distillation. This method, with the quantity of sample and the apparatus above mentioned, is accurate to less than 0.03 of 1%.

CONCLUSIONS.

Method 1 is approximate and applicable to heavy oils and greases only.

Method 2 is approximate and applicable to thin oils. A diluent is to be avoided.

Method 3 is like method 2, but is more rapid, and somewhat more accurate.

Method 4 is convenient and, with petroleum, accurate to approximately 3% of the water percentage.

Method 5 is convenient and accurate.

Methods 6 and 7 are approximate only.

Method 8 is successful in breaking up an emulsion on a commercial scale or in reducing the water content of an oil to such a condition that it can be successfully treated in some other manner.

Method 9 is accurate to approximately 0.033 gm. of water per 100 c.c. of benzene and oil in the distillate.

Method 10 is convenient and can be used simultaneously with a distillation. It is accurate to about 0.003 gm. of water in the distillate if the water is cooled to about 2° C.

than white bread, it yields up less of these substances to the digestive process. The most reliable nutrition experiments with respect to the digestibility and available energy of bread made from different types of flour afford this data:—

	% Available Energy.
Graham flour	83
Entire wheat flour	87
Standard patent flour	91

"This table would show that white flour presents a greater availability of energy than most articles of food on the average menu."

A Promising Colonial Industry.

At the end of last year an Australian gentleman obtained a twenty years' lease for the exploitation of bat guano deposits in Mount Etna's caves, Queensland. These deposits extend over nearly 300 acres in the vicinity of Rockhampton, and are situated within one mile from a railway. The Californian farmers prefer bat guano from Mexico to all other manures, as it has a large percentage of lime, and resembles in other respects Peruvian guano, though not quite so rich in nitrogen or phosphoric acid. It is of light brown colour and contains the cores and hair of the bat. By contact with carbonic acid in the solution of the lime and water, part of the nitrogen is vitrified, and is found back in small, agglutinated lumps.

Though the upper layer of the Mount Etna deposit is poor, the lower one is as high as 22% in nitrogen. The caves being of a constant temperature of about 50° F., no evaporation takes place, and all nitrogen proved in fresh excreta is found back, disintegrated in the deposit, as nitrate, ammonia, and organic nitrogen, varying in percentage as one goes down. The material is dried outside the caves, then shipped to the blenders and manure manufacturers, who fix the units for the intended crops. It is admitted that an organic manure is better than the superphosphate rock, because, after the principal fertilising element is spent, the remaining organic matter increases the humus of the land. With the bounty now granted by the Commonwealth on locally manufactured manures, this deposit may prove of considerable advantage to the colony.

Satisfactory Earnings of the Leading Chemical Firms in Germany.

An interesting table of the dividends paid by some leading German chemical firms, doing a large business in England and the British Colonies, has been compiled by the *Manchester Guardian*. It shows that most of these firms have been able to maintain their previous rates of dividend during the past year. In some cases the dividends have been increased.

	Dividends	
	1911.	1912.
	%	%
Aktiengesellsch. f. Anilin-Fabr. ..	20	20
Badische Anilin- und Soda-Fabr. ...	25	25
Farbenfabriken Fr. Bayer & Co.	25	25
Meister Lucius and Bruning ..	27	30
Vereinigte Glanzstoff-Fabr. ..	36	36
Aktiengesellschaft Schering ..	12	13
Chemische Fabr. von Heyden ..	12	14
Chemische Fabr. J. D. Riedel ..	12	12

The first four of the above-named firms do a large business in this country in aniline dyestuffs. The

COMMERCIAL AND GENERAL NOTES.

The Nutritive Value of Flour.

The chemists and physicians of the American Medical Association, Chicago, have spent much time in analysing various kinds of flour in order to compare their nutritive value. In an article on these tests recently published by the *North-Western Miller*, white flour has proved to be the best. The author of the article in question says: "The question of relative food values of different kinds of bread has been debated since the days of Sylvester Graham, the man who claimed he was cured of the drink habit by eating bread made from whole wheat flour. Investigations show that while whole wheat bread carries more protein and ash

⁴⁸ Allen, I. C., *Op. cit.*, p. 28.

Vereinigte Glanzstoff Fabriken produce large quantities of artificial silk and the last three firms manufacture chiefly pharmaceutical products, and export largely to the United Kingdom and the Colonies. It is remarkable that, although there has been little change in the dividends declared, there have been considerable fluctuations during the past year in the prices of the shares on the Berlin Stock Exchange. These fluctuations must be attributed to political causes because the chemical trade in Germany was brisk throughout 1912.

Decreasing Use of Quinine in the United States.

Despite the growth in population in the United States the imports of quinine are gradually decreasing owing to a variety of causes. The drainage of swampy districts, the better screening of homes, and the discovery of the relation between mosquitoes and fevers generally, have had a large share in reducing the prevalence of diseases for which quinine is largely taken, while the development of the chemical industry has brought into use a number of coal-tar and other preparations which share with quinine its popularity as a remedy of fevers.

Cinchona, or Peruvian bark, is the generic name of a number of trees indigenous to Peru, Ecuador, and Bolivia, formerly the chief producers of that article. Later, the tree was transplanted to Java, India, Ceylon, and other countries where its cultivation was largely developed. Germany is the chief source of the quinia and the various salts extracted from cinchona bark imported into the United States. Of the 3,219,000 ozs. imported in the fiscal year 1911, 1,958,000 ozs. came from Germany, 83,000 ozs. from England, and 946,000 ozs. from the Netherlands.

Glass for Chemical Instruments.

A Swedish scientist, Mr. Wolf Burckhardt, claims to have discovered a new process for improving quartz glass. It is called "Syloxyd" and is especially suited to the manufacture of pipes, tubes, receptacles, flasks and other instruments used in chemistry. Most of the articles used for such purposes have been made of platinum.

Articles made by the new process from electrically fused quartz, because of the low coefficient of expansion, can be subjected to extreme changes of temperature. It is now possible to make articles of large dimensions of this glass, such as socket pipes and acid bottles. Vessels holding as much as 25 gallons have been made from it.

The new process consists of adding to the raw quartz solutions of oxides of zircon, titanium and other metals difficult to fuse. The resulting mixture gives a transparent glassy substance which melts at a temperature of 1,750° Centigrade. The advantage claimed for this material is that its strength is 30 to 50% greater than quartz glass tested by bending, and 10 to 30% more tested by pressure.

A Substitute for Gasoline.

The American Standard Oil Co. has announced the interesting fact that a substitute for gasoline had been discovered after many experiments. It will be called Motor Spirit and marketed shortly. The new fuel is an additional by-product of petroleum and is the discovery of W. M. Burton. The spirit has a greater range of boiling points than gasoline, allowing the motor to be started more easily, it is cheaper than gasoline and is said to furnish 25% more mileage.

By the discovery of the spirit the output of fuel for gasoline engines from a given amount of crude petroleum is declared to be practically doubled. Motor Spirit resembles gasoline closely, except that it is yellow in colour and has a pungent smell. The company intends it for use in motor trucks and stationary engines. The great consumption of gasoline by motors has been threatening the available supply for some time and caused a sharp advance of prices. The production of gasoline in the United States cannot be reckoned with any degree of certainty, but taking the estimated production of crude oil in the country in 1912, and the average refining characteristics of the various grades, one may figure on a yield of gasoline around 15,000,000 barrels on the presumption that all of the production was treated for the lighter distillates.

Spinning Nettle Fibre.

The spinning department of the Kaiser Franz Joseph School for Textile Industry at Reichenberg, in Bohemia, has carried out extensive experiments with the spinning of nettle fibre. By a new process, the invention of an Austrian chemist, the fibre is decorticated and after cleaning it, spinning may be commenced. The produced yarn is said to be particularly suitable for tapestries, damasks and furniture covering, etc. The inventor also claims to be able to produce a pure spinning fibre from hops and other fibrous stalks by the new process.

A factory for spinning nettle fibre on a large scale will shortly be opened in the province of Schleswig-Holstein in Germany. The fibre yields the finest yarns which may be used either alone or mixed with other textile yarns, such as wool, cotton, silk, etc.

The ever-growing need for new fibres of a serviceable nature is such that this experiment will be watched with some attention as in the case of recent developments in wood pulp yarn.

"Artificial Wood" from Straw and Dried Grass.

The annual consumption of wood in the manufacture of matches is next to incredible. In view of the scarcity of lumber and its consequent high price, an efficient substitute is of economical importance. A material which the inventor calls artificial wood, is mentioned by a Canadian tobacco journal of recent issue. It is a composite made of straw and dried grass. The raw material is passed through crushing rolls, thence through cylindrical cutters which divide it into strips, and afterwards it is supplied with an adhesive. The strips inclosed at both ends with layers of paper, are forced through other rolls and through linked moulds in the form of a chain, where they are subjected to heat and pressure, whence they emerge in the form of round splints.

Examinations of Oleo-resins from Western Pines.

An interesting report on the examinations of oleo-resins of some western pines has been published by the Bureau of Forestry, United States Department of Agriculture (Bull. No. 119). The bulletin has been prepared by the Government chemist in forest products and gives a full description of the work, the properties and composition of oleo-resins, methods of examinations, etc. The bulletin is of a highly technical character and very instructive. Readers interested in it may obtain a copy from the Superintendent of Documents, Government Printing Office, Washington D.C., at a cost of 5 cents exclusive of postage.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.

1002/12. E. A. ASHCROFT, London. **Alkali Metals.** 12 January, 1912.

The manufacture of compounds of the alkali metals from alloys thereof is characterised by first extracting the alkali metal from the alloy by means of a fused melt of the product to be obtained and subsequently, and quite apart from the heavy metal of the alloy, reacting with the necessary reagents. (8 claims.)

1953/12. A. HEINEMANN, London. **Turpentine.** 24 January, 1912.

For the depolymerisation of turpentine oil or crude turpentine into compounds boiling below 100° C., especially isoprene, the process consists in first admixing steam, preferably superheated steam, with the vapours of turpentine oil or crude turpentine, and then passing the mixture over suitably heated surfaces. (1 claim.)

2149/12. O. EBERHARD, Heidenau. **Removing Carbon disulphide.** 26 January, 1912.

A process for removing carbon disulphide from gases or liquids consists in treating the gas or liquid with primary or secondary amines in the presence of water and the hydrates, sulphides or sulphydrates of the alkali and earthy alkaline metals. (2 claims.)

2328/12. L. G. LEFFER, Wevelinghofen. **Hydrocarbons.** 29 January, 1912.

A process for converting hydrocarbons of higher boiling point into those of lower boiling point is carried into effect in the presence of three combined conditions, viz., the accurate regulation of the pressure of the pressure medium, the constant circulation of the pressure medium, and a working temperature not exceeding 410° C. (5 claims. 1 Fig.)

3870/12. BADISCHE ANILIN AND SODA FABRIK, Ludwigshafen-on-Rhine. **Dihalogen Hydrocarbons.** 15 February, 1912.

Relates to the production of 2:3-dihalogen-2-methyl-butane, and of homologues thereof, by treating, with chlorine, or a compound which gives rise to chlorine, 2-halogen-2-methyl-butane, or a homologue thereof, which is a 2-methyl derivative, while in the state of vapour. (4 claims.)

4692/12. A. G. SUNDBERG, Helsingborg. **Copper.** 24 February, 1912.

In the purification of copper by blowing a scorifying agent and a combustible in the molten metal beneath its surface, carbonate of sodium or of potassium or both, in a finely divided state, are used according to this invention as a scorifying agent. (1 claim.)

6652/12. E. L. RINMAN, Harnäs. **Soda Regeneration.** 23 March, 1911.

Soda is regenerated, and alcohols and ketones recovered from waste liquor of soda and sulphate pulp-mills by exposing salts of organic acids obtained from or contained in the waste liquor, separately or several of them together, or all together to dry distillation after the addition of a strong base or bases. (4 claims.)

8230/12. BADISCHE ANILIN AND SODA FABRIK, Ludwigshafen-on-Rhine. **Anthracene Compounds.** 4 April, 1912.

Compounds of the anthracene series are manufactured by condensing an ester of 1-nitro, or 1-halogen-, anthraquinone-2-carboxylic acid, or a derivative of these compounds, with ammonia, or with a primary, or secondary, amino compound, and then saponifying the product obtained. (4 claims.)

8511/12. BADISCHE ANILIN AND SODA FABRIK, Ludwigshafen-on-Rhine. **Tanning.** 10 April, 1912.

Materials suitable for use in tanning are manufactured by condensing, under mild conditions, phenol, or a sulpho-acid thereof, with sulphuric acid and formaldehyde, so that the proportions of reagents combined do not vary substantially from one part of formaldehyde, two parts of sulphur and two parts of the aromatic compound. (8 claims.)

8872/12. FARBENFABRIKEN VORMALS FRIEDRICH BAYER & Co., Elberfeld. **Azo-dyestuffs.** 15 April, 1912.

New basic mono-azo-dyestuffs are manufactured by combining the diazo compounds of aminobenzylamines, of aminobenzylpyridines or of aromatic ammonium bases either directly with 1:3-dioxyquinoline or in combining them first with an aromatic amine, diazotising the intermediate products thus obtained, and finally combining the diazoazo compounds thus produced with 1:3 dioxyquinoline. (3 claims.)

11568/12. F. RASCHIG, Ludwigshafen-on-Rhine. **Explosive.** 15 May, 1912.

An explosive according to this invention contains ammonium nitrate and as a combustible agent the dry residue obtained on the evaporation of the waste lyes formed in the production of cellulose sulphite. (4 claims.)

11587/12. FARBENFABRIKEN VORMALS FRIEDRICH BAYER & Co., Elberfeld. **Formic Acid Esters.** 15 May, 1912.

Esters of dialkylamino-formic-acid are produced by treating chloro formic acid esters with trialkylamines and decomposing the ammonium halogenides thus obtained. (3 claims.)

14369/12. G. B. SCHWERIN, Frankfurt-on-Main. **Separating Colloidal Substances.** 19 June, 1911.

The invention relates to a process for separating colloidal, soluble, or finely divided substances from matter serving as a carrier, and consists in subjecting the mixture to electro-osmosis. (4 claims.)

17430/12. SUDFELDT & Co., Melle. **Deodorising Train Oil.** 26 July, 1912.

A process for deodorising train oil consists in adding to it higher fatty acids and distilling the mixture in a vacuum at a low temperature until the odoriferous bodies and volatile acids occurring in the oil are driven off, and the escaping vapours are free from odoriferous substances. (2 claims.)



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The London University.

In their final report the Royal Commission on University Education in London recommends an almost complete reorganisation of the University of London.

The report is a unanimous one and condemns the view of a separate technological university, having the Imperial College as its centre. The Commissioners have come to the conclusion that the existing organisation is fundamentally defective, on account of the present relations of the internal and external sides of the University, and of the different educational standards and aims of the large number of institutions related to it.

They have definitely decided that technological instruction should be dealt with, and that a University Press should be established. The Commissioners pronounce against the external degree and condemn the set syllabus as being "inconsistent with the true interests of university education, injurious to the students, degrading to the teachers, and ineffectual for the attainment of the ends they are supposed to promote."

They believe that a system of external examination is always based upon want of faith in the teachers, and consider that "degrees should not be awarded upon examination alone, but be practically the certificates given by the professor upon the whole record of the student's work."

The result is uneducational methods of work. They consider that it is a fallacy to assume that self-education is achieved by any but the very exceptional man, or is induced by examination.

An additional income of £85,500 will be required for professorships and laboratories, but no suggestion as to methods of raising this is put forward. The scheme is a drastic one, and supports the contention that some very definite change is needed to place the London University on a satisfactory basis.

It would seem that after all the University is to be centred in Bloomsbury, and the Central University buildings will include a great hall for university ceremonies, accommodation for the Senate, and for the meetings of Convocation. A Central University library, and a club-house for the union societies, headquarters for the Officers' Training Corps, and rooms for professors, etc., are also required.

The University will establish and maintain, out of the funds specially raised for the purpose, hostels, preferably in the suburbs, where students may live together, irrespective of the faculty to which their studies belong.

A definite step is taken in the official sanction of the establishment of London as a general technological centre, and this will, we think, be welcomed by all those who believe that students of the London University should be encouraged to enter the industrial side of scientific practice.

The definite formation of a Committee for Technology—three-fourths of which number will consist of men of affairs and persons with special scientific knowledge of the professions and industries concerned—is suggested. This committee will control :—

1. The annual income received by the governing body of the Imperial College, and the use of all land and buildings available for that institution.

2. The annual income received by the University in respect of the departments of engineering at University College and King's College, and the use of the land and buildings at present available for them so long as those departments are maintained.

3. Any additional funds and buildings the Senate may see fit to assign for the purpose.

The publication of this report will clear the air, and give a new impetus to university life. In fact it will make this possible for London. The difficulties still to be faced are of no mean order. The financial position will probably have to be faced by the Government or the London authorities. London must become one of the world's great centres of training and research, and for the first time this report indicates definite lines of progress.

The Scientific Method.

In an entirely characteristic series of articles which has recently appeared in one of the daily papers, Mr. H. G. Wells has drawn attention to the need for a great system of laboratories and experimental stations, with a view to increasing the type of man which it is generally assumed will be required to deal with future

scientific developments in this country. Even if one cannot agree with the general views as expressed in these articles, or with all the conclusions arrived at, his remarks are of interest, especially in view of the fact that the Government have announced their intention of dealing with the present educational system on general and exhaustive lines.

Mr. Wells points out that we are to-day spending 18½ millions a year upon education out of the national funds, but that only about 4 millions a year of public money is devoted to education "above the simple democratic level." Nearly 30 millions in all for the foundations, and only a seventh for the edifice of will and science. He then inquires in his characteristic way:—

"Is it any marvel that we are a badly organised nation, a nation of very widely diffused intelligence, and very second-rate guidance and achievement? Is it any marvel that directly we are tested by such a new development as that of aeroplanes or airships we show ourselves in comparison with the more braced-up nations of the Continent, backward, unorganised, unimaginative, unenterprising?"

He goes on to point out the need for the presence of a braced-up class, which has enterprise, knowledge and invention. Such a movement, he concludes, would develop a strength and create a tradition which would not rust or grow old-fashioned in the years to come. Speaking of the defensive position, with which opinions again we do not necessarily associate ourselves, he says:—

"Our supreme want to-day—if we are to continue a belligerent people—is a greater supply of able educated men, versatile men capable of engines, of aviation, of invention, of leading and initiative. We need more laboratories, more scholarships out of the general mass of elementary scholars, a quasi-military discipline in our colleges and a great array of new colleges."

In view of these remarks the same authority's opinion on the advantage of training ordinary type of men in research has an interest, and in this respect he may be quoted from another recent source.

"The trained investigator is quite the absurdest figure . . . he is like a bath-chair perpetually starting to cross the Himalayas by virtue of a licence to do so. For such enterprises one must have wings."

"Such men are producing great bulky masses of imitative research, futile enquiries, and monstrous entanglements of technicality about their subjects, and it is to their instinctive antagonism to the idea of a 'gift' that we owe the preposterous conception of a training for research."

If this view is correct, and the true investigator is born and not made, can we reasonably hope to provide a system under which the right kind of student would be found for such colleges?

The whole position is a difficult one. One can only judge by practical results obtained on a large scale, and here we may possibly look with advantage to Germany for a provisional answer to such a question.

A programme which aims at turning out a succession of Faradays or Pasteurs through the medium of a college training is dealing with a hopeless task. Such men are not the *product* of any college course. They exist. That the colleges can train other minds in the principles of science is, of course, beyond question; and the accumulated work of such men may determine, in conjunction with the work of the great pioneers, the future of any country, if they will at the same time specialise in common sense.

The position might possibly be summed up by saying, that the man with the "gift" must have the opportunity of working under the best conditions. Others may be trained to deal with, and carry on, the more general advance in scientific learning and application. Now and again one of these investigators will step out into the first rank through the originality of his work.

Fuel Testing.

In this connection the Bulletins issued by the U.S.A. Department of the Interior under the direction of Mr. Joseph A. Holmes are well worth the attention of those connected with industrial chemistry.

For example, *Bulletin No. 42* deals with the comparative fuel values of gasoline and denatured alcohols in internal combustion engines. The experimental data which has been published in this case is certainly very complete. The publication runs to 234 pages, and contains thirty-four tables of data, which it would be difficult to find elsewhere. It is fully illustrated by a number of illustrations, curves and indicator diagrams.

Another publication which may be given as an example is *Bulletin No. 18*, dealing with the transmission of heat into steam boilers. The same thoroughness in treatment is observed in this case. Experiments were carried out with small metallic tubular boilers of standard types, and full particulars are given as to the methods of testing and calculation employed. Here again a series of curves, illustrations and tables illustrate the varying results obtained.

These publications, and the accompanying technical papers which are of the same order, but relatively less comprehensive, deal with fuel testing in its many aspects, including the volatile matter of coal; the coke industry of the United States; producer gas-power plant developments in Europe; washing and coking of coal; transmission of heat through furnace walls; briquetting tests of lignite; the use and value of peat for fuel; smokeless combustion of coal in boiler furnaces; and many other points of almost equal importance. The data given is apparently in most cases published for the first time, and the reports, as they stand, are undoubtedly of value to the practising chemist or engineer.

The authorities are certainly to be congratulated upon the success of this venture.

FUTURE OF THE BRITISH BEET SUGAR INDUSTRY.

By THE RT. HON. THE EARL OF DENBIGH, C.V.O.

ATTENTION of late has been increasingly drawn to what is called the rural problem; in other words, the continued diminution of our rural population and the insufficiency of their wages to pay an economic rent for proper housing accommodation. This problem has become more and more acute owing to the concentration into the urban areas of industries which formerly were carried on to a large extent, but in small units, in the various villages. The result has been to make the rural population more and more dependent, in many districts entirely so, on the farmer for employment. Farming profits diminished and millions of capital invested in the land were lost during that period of agricultural depression which appeared in the late seventies, brought about by the great opening and development of oversea corn lands. We are now realising the evil effects which follow on the neglect of a country's agriculture.

Nothing is more significant than the different manner in which this question has been handled by ourselves and Continental nations. Germany especially, realising the importance to the nation of a strong agricultural community, appreciated the necessity of doing everything to encourage that great sugar industry which is so closely allied with agriculture and which provides so much employment in the rural districts. But Germany is not alone, and other countries have also appreciated this fact, and have given every encouragement to the introduction of capital for the erection of sugar factories and for the cultivation of the beet to supply them. We here in England have persistently neglected the whole affair, and so long as we were able to buy cheap sugar from abroad we seemed quite content to let things slide.

The agitation which has been aroused in the past few years for the purpose of calling attention to the real facts of the case as regards the sugar industry has at last been bearing some fruit. At first we had to encounter an extraordinary amount of ignorance and prejudice. It was said that our climate and soil were both unsuitable, our labour supply insufficient, and our farmers antagonistic to the sugar beet industry in this country. Persistent experiments have shown that our climate is, if anything, more suitable than that of the Continent, and both in wet seasons and dry seasons the sugar contents obtained have been most encouraging.

There is a large expanse of land eminently suitable for the culture of sugar beet, and by means of this crop I believe that some millions of acres, which have now gone down in poor grass land, could be once more brought under the plough, and made to bear payable crops. The labour is a matter of organisation, and the farmers, or at least the more enterprising of them, are beginning to under-

stand the arguments advanced on behalf of sugar beet.

A great step forward was made last year when, owing to the enterprise of the Anglo-Netherlands Company, a combination of English and Dutch interests was effected and a factory erected at Cantley, some ten miles from Norwich. That has done more than anything else to bring home to the British people the undoubted fact that a large and important industry is simply waiting our notice, and requires nothing but capital and organisation to make it go.

One of the attractions of the beet sugar industry is its extraordinary diversity of interests. Let us begin with the agricultural side first, as that after all is the most important, and in a way the most difficult, because the introduction of sugar beet on a large scale must necessarily to a great extent alter our present system of farming wherever it is grown. Experience on the Continent has shown that the larger factories pay the best, consequently all the new factories now being erected are considerably larger than used to be the case. The factory capacity now recommended is one of 1,000 tons a day, working for say 90 to 100 days in the season. The provision of nearly 100,000 tons of roots is a serious matter, and at 14 tons to the acre, which we ought to get in this country, would mean 6,000 or 7,000 acres under beet within a reasonable distance of the factory either by road, rail or water. As this beet requires careful preparation of the land, sowing, singling, weeding (several times), lifting, and transporting to the factory, it will be seen that the roots alone require a large amount of labour. This will include a very considerable amount of traffic for the local railway. Then there is the factory, which, to deal with the above-mentioned body of roots, would probably cost about £150,000, of which some two-thirds would certainly be expended in plant and machinery. Here you have ramifications going off into the engineering trades and a great deal of the plant coming under the designation of what is known as chemical engineering.

At the close of the actual "campaign," as the actual operative season of a sugar factory is called, labour does not by any means entirely cease, as some people seem to imagine, but a large staff of mechanics has to be kept on there for the greater part of the year. The whole plant is taken to pieces, cleaned and repaired, and got ready for next season's run. A very considerable amount of local skilled labour is therefore required, whilst much of the unskilled labour which was utilised during the "campaign" itself will find work on the land in farming operations.

There is no question but that a sugar beet factory in a district is the centre of industry. Houses have

to be built for its employees, the demand for labour gives an additional impetus to cottage building in the locality, thousands of tons of coal are required, and large numbers of bags for packing and transporting the sugar. There is no industry in the world which in any way resembles the sugar beet industry having regard to its many-sided aspect and the extent to which it is dependent upon agriculture.

The main difficulty with our farmers here is that of introducing a new crop which has to be handled differently and sold for cash instead of being consumed by stock. Once the farmers realise this latter point the proposition generally becomes extremely attractive to them, because it enables them to have an excellent cleaning crop in their four years rotation and one on which they can make money instead of, as a rule, making a loss. Turnips and mangels, the former especially, very frequently come out at a loss to a farmer, but they are grown for the purpose of improving the land, and on light soil to enable sheep to be hurdled and fed on the land. That, however, can still be done to a considerable extent in conjunction with sugar beet crops. The sugar beet grows a very heavy head of leaf, and last year, in a wet season, the tops in many cases weighed even more than the roots. These tops are cut off and left on the ground and constitute an excellent sheep feed, or if not required for that they are good manure and can be ploughed in. The British farmer, however, is a most conservative person and it takes time to induce him to adapt himself to these new methods. Those who have tried it are now becoming fully alive to the fact that it is a great advantage to be able to grow a good clearing root crop which you can sell for cash in the autumn without having to wait a long time for any return until you have put it through stock.

A very interesting report has just been published by the Harper Adams Agricultural College at Newport, Salop, dealing with experiments they have been carrying out in testing the comparative feeding properties of sugar beet slices and mangels.

The report is all in favour of the slices, which are dried at the factory and then soaked in water before use.

They form an extremely handy and convenient article of cattle food—no pulping or slicing is required as with mangels and other roots—their weight is small and they can be easily stored. On the Continent they are used in enormous quantities for all classes of stock including horses, and they only require to be properly known and tested here in order to win approval.

The main difficulty at the present moment is that of obtaining capital for the purpose of starting a factory. In an industry such as this the initial expenses are bound to be quite abnormal for the first few years. Until the farmers have had experience, and have acquired confidence in the new crop, and until they have learned how to handle it, and to organise the necessary labour in the districts so as to have a sufficient quantity when the rush time comes in the autumn, it will be difficult to get many

farmers to grow large quantities of beet. The consequence is that factories will have to be dependent upon a wide area for their supplies, all of which means extra expense and extra freight. An extra 2s. per ton of freight paid on 50,000 tons of beet is £5,000, a very considerable item to come off the year's profits if sugar prices should happen to be low. No factory can give its best results unless run at its fullest capacity, and I think it will be found to be quite a difficult matter to make certain of the full supply of 100,000 tons of beet in any locality straight off the reel. If, in the first year of a factory's working, the crop on the Continent should happen to be low, and sugar improved by £2 or £3 a ton, all well and good. There would no doubt be a good return on the year's working, but if prices are normal as they are to-day, it will be a different matter altogether, and it is this uncertainty which makes it necessary for an industry like this to be helped and fostered in its initial stage.

However we are moving. People are at last beginning to realise that all the sugar we consume here is *not* cane sugar, and they are learning that three-quarters of our sugar supplies are made from sugar beet and come from the Continent of Europe. So they are now asking more and more: if other European countries find it worth their while to do all they can to encourage this industry, why should we not do the same?

High Pressure Reactions: The Formation of Coal and of Hydrogen.—Dr. F. Bergius alluded to the work of Haber and Le Rossignol, and to his own work on the oxidation of calcium oxide to peroxide under high pressure, before the Society of Chemical Industry, and briefly described the preparation of hydrogen of 99.95% purity by the action of iron on liquid water at high temperatures and pressures. It was shown that the presence of electrolytes increased the velocity of the reaction, which was not merely superficial, as the iron was oxidised throughout to Fe_3O_4 . The operation had been carried out on a large scale.

The author also referred to the carrying out of exothermic reactions under regulation, such as the decomposition of pure cellulose and of peat. By heating such substances under pressure at 340°C . for 8 to 61 hours, a substance resembling soft coal was produced, together with carbon dioxide and water. The author calculated, from the rate of production of this substance, that about 8 million years would be required, under the probable conditions of formation of coal in nature, for the production of a coal of similar composition.

The substance possessing the chemical properties of coal can be made to acquire its physical properties by further great compression. At extremely high pressures a substance of high carbon content and possessing the physical properties of anthracite is produced.

A description of the reaction vessels and cone joints by the aid of which he could maintain very high pressures for prolonged periods was also given.

An interesting discussion followed the paper, in which Professor H. E. Armstrong and others took part. In reply to a question Dr. Bergius stated that he had actually isolated liquid hydrocarbons from the water surrounding the cellulose mass. These were present in a colloidal state.

ELECTRICAL AND THERMAL DISINTEGRATION OF METALS.

By G. W. C. KAYE, B.A., D.Sc.

THE disintegration of metals when heated in high vacua, and in particular at temperatures below their melting points, forms an interesting field of study, to which a good deal of attention has recently been paid. It has long been known that similar volatilisation effects can be obtained without the application of heat by charging a metal with high-tension negative electricity in a vacuum. Such electrical evaporation—as Sir William Crookes called it many years ago—is indeed far more acute than that produced by thermal means: a moderate negative charge is as effective as intense heat in facilitating the escape of the outlying molecules from the rest of the metal.

While the two sets of disintegration phenomena resemble each other closely, it will be convenient, in giving an account of the whole subject, to consider the electrical and thermal effects separately.

ELECTRICAL DISINTEGRATION.

Workers with discharge tubes have long been familiar with the fact that when an electric current is passed from an induction coil through a vacuum tube provided with platinum electrodes, the glass adjacent to the negative pole (or cathode) often becomes blackened with a mirror of metallic platinum.

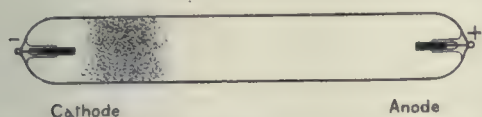


FIG. 1.—PLATINUM MIRROR IN VACUUM TUBE.

The positive electrode (or anode) on the contrary, shows little or no such effect (Fig. 1). This cathodic "sputtering" or disintegration is a feature possessed in greater or less degree by all metals. The effect appears to have been noticed in the very early days of vacuum tubes—Plücker remarked on it in 1858, and Dr. Wright, of Yale, used the method to platinise glass in 1877. The subject was investigated by Sir William Crookes in 1891, by Granquist at Stockholm in 1898, by Holborn and Austin at the Reichsanstalt in Germany in 1904, by Houllevigue in France (1909-10), and more recently by Kohlschütter and his coadjutors, whose work is described in an extended series of papers in the *Zeitschrift für Elektrochemie* (1906-12).

There are three main emissions from the cathode in a discharge tube. Of these, the best known is the cathode rays—the negatively-charged electrons of sub-atomic size which leave the cathode surface at right angles, and which in all probability carry most of the current through the tube. Their

nature is entirely independent of both the gas in the tube and the material of the cathode.

The second emission is the positive rays, or "canalstrahlen," the bulk of which travel in a direction opposite to that of the cathode rays, and so pass through any hole there may be in the cathode. The positive rays are positively-charged high-speed molecules of the residual gas in the tube.

The third emission, with which we are now concerned, consists of particles of disintegrated metal from the cathode. They appear to be projected normally (at any rate very approximately) from the cathode and to travel in straight lines; so that, under suitable conditions, the sputtered image may possess the outlines of the cathode. The streams of metal are negatively charged and it is found that they only deposit on surfaces which are positive with respect to the cathode; for this reason they do not readily deposit on a plate which is exposed to the bombardment of cathode rays. It does not appear that, in ordinary circumstances, the disintegration of the cathode plays any appreciable part in the passage of the current. In contradistinction to the cathode rays, which are very readily deflected by a magnet, the sputtered particles require strong magnetic fields (2,000 gauss upwards) before any deviation of their path can be detected. The probable inference would be either that the particles are very fast moving or that they are relatively large aggregates of molecules; the latter view is supported by other evidence. The lower the pressure in the tube and the higher the potential applied the farther are the particles hurled. The sputtered metal does not appear to excite phosphorescence when it strikes the glass.

Cathodic disintegration is not a simple phenomenon, and even now the exact mechanism of the production of the sputtered particles is doubtful. However, experiment shows that the amount of metal shot from a cathode depends on the following factors:—

- (1) The nature of the cathode.
- (2) The temperature of the cathode.
- (3) The nature of the gas.
- (4) The current through the tube.
- (5) The fall of potential at the cathode.

It will be useful to treat the subject from these points of view.

(1) *The Nature of the Cathode.*—Crookes in 1891 was the first to investigate systematically the relative sputtering of a number of metals under the same conditions of discharge. The cathodes were of wire, 0.8 mm. thick, except for the more fusible metals such as tin, lead and cadmium of which thicker electrodes were used.

The residual gas was air; the pressure, that

corresponding to a dark space 6 mm. thick (say, 0.05 mm. Hg.). In these circumstances, the relative losses of weight at ordinary temperatures came out roughly as follows :—

CATHODIC SPUTTERING.

(Palladium = 100.)

Palladium	100	Copper	37
Gold	92	Cadmium	31
Silver	76	Nickel	10
Lead	69	Iridium	10
Tin	52	Iron	5
Brass	47	Aluminium	0
Platinum	40	Magnesium	0

The order of these metals must not be regarded as inviolable. It is affected to some extent by a change in the pressure of the gas (which may, for instance, put platinum above gold, see Fig. 2), the nature of the gas or the temperature of the cathode (see later). Nevertheless, the sequence which, with the exception of Ir, Pb, Sn, and Cd,¹ is roughly that of the voltaic series, is of value to users of discharge tubes in general and of X-ray tubes in particular. The reason for the general choice of aluminium as the material for the electrodes of discharge tubes, is apparent; though it is not right to assume that it is impossible to make aluminium sputter appreciably, as will be apparent from a scrutiny of the cathode of an old X-ray bulb. Tantalum has also proved to be an excellent material for cathodes, possessing as it does, marked freedom from sputtering. Tungsten, I believe, displays equally good properties.

As a result of the more recent work of Holborn and Austin and of Köhlschütter, it appears that, *ceteris paribus*, the amount of sputtering is roughly proportional to the chemical equivalent of the metal. The truth of the rule has been vigorously contested in some quarters; and undoubtedly some metals either do not conform to it at all or require to be credited with variable valencies.

(2) *The Temperature of the Cathode.*—If the temperature of the cathode is raised appreciably, either by extraneous means, or by the passage of the discharge itself, the sputtering of the less refractory metals such as tin, cadmium, or lead is markedly increased. An idea of the order of the effect may be got from Crookes' experiments on cadmium, in the course of which he obtained the following results :—

Temperature of Cathode.	Loss of Weight of Cathode.
200° C.	0.65 gramme/hour
230°	1.0 " "
About 320° (M.P.)	About 8.0 " "

Evidently in the region of the melting point the

electrical evaporation becomes pronounced; the same thing holds doubtless for other metals at corresponding temperatures.

The increased disintegration with temperature-rise probably accounts for the fact that when the conditions in a tube are such that excessive sputtering is taking place (*e.g.*, with aluminium in argon), it is not uncommon for the electrodes to become red hot or even melt, showing that the temperature is probably largely responsible for the rapidity of the disintegration.

There is one curious connected effect familiar to many workers, and that is the reddish glow which a cathode often assumes while it is volatilising. The appearance, which suggests that the surface is red hot, disappears at once when the current is turned off. It would be interesting to test if the effect is a true indication of incipient surface heating. Some support is given to the notion, as Crookes has remarked, by the graphitic changes which the surface of a diamond undergoes when used as a cathode.

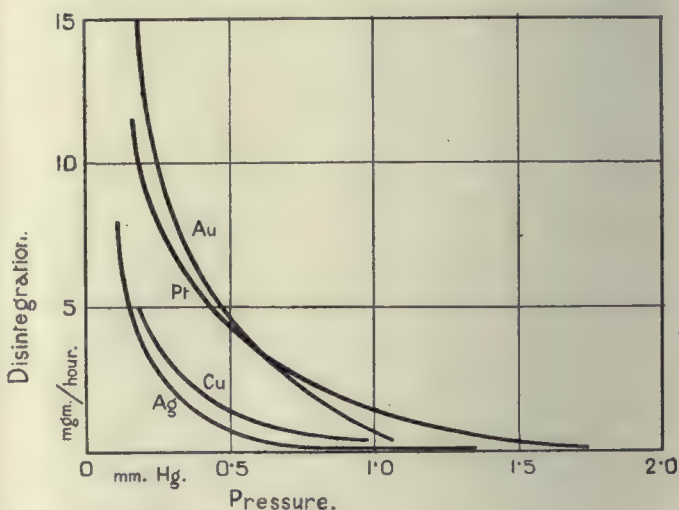


FIG. 2.

(3) *The Nature of the Gas.*—The nature of the residual gas has a very marked effect both on the degree of sputtering that a metal exhibits as well as on the appearance of the deposit. Hydrogen, nitrogen and carbon dioxide are in most cases unfavourable to the effect, while oxygen and especially the monatomic gases, Hg. vapour, He, A, Ne, Kr and Xe, bring about pronounced disintegration of most metals. Helium shows the effect least of all the inert gases, but argon is particularly potent, and metals so varied as Al, Ag, Cd, Pt and Au are all excited to a maximum activity in this gas. Cadmium displays the effect in argon to a degree even at ordinary temperatures; for instance, Köhlschütter records in one experiment a volatilisation of nearly 150 mgms. in half an hour, while aluminium under the same conditions gave but 1 mgm. In another experiment, platinum volatilised some 20 times as fast in argon as in hydrogen; the effect with platinum and gold is still greater in nitrogen and oxygen. Aluminium shows only feeble

¹ These exceptions are probably due to thermal effects.

sputtering in hydrogen, oxygen, or nitrogen. Iron responds scarcely at all to a change in the gas.

Kohlschütter and Stoll (1912) have recently paid special attention to the cathodic sputtering of silver in an atmosphere of hydrogen, nitrogen or argon. The appearance and behaviour of a film of metal so prepared is affected by and is peculiar to the gas employed, a feature that is further brought out in the ultramicroscope. The finest state of sub-division is produced in argon, the coarsest in hydrogen: this is reflected in the electrical resistance which, for a given mass of metal, is greatest in the hydrogen deposit and least in the argon. If these films are left to themselves the smaller particles segregate spontaneously into larger particles, and thus small patches of denser deposit are formed at the expense of thinner regions where the film may eventually tear in consequence. This is responsible for the resulting increase in general transparency of the film, with a corresponding large and rapid rise in the resistance. The segregation may be retarded by increasing the pressure of the gas, so that possibly the effect is one arising out of a greater vapour pressure of the smaller particles which are accordingly more volatile.

The chemical activity of some of these cathode deposits is pronounced; it is largely controlled by the nature of the residual gas in which the film was deposited. For example, platinum volatilised in argon is a very energetic catalyser; that in hydrogen but feebly so. A silver deposit obtained in argon is rapidly oxidised in air at 100° C., but the coarser deposit in hydrogen is much less susceptible.

(4) *The Current Density in the Discharge Tube.*—Granquist found that at constant pressure the loss of weight of a cathode was roughly proportional to the square of the current density (*i.e.*, the average current per unit area of the cathode). Other workers maintain that the disintegration is more nearly proportional to the first power of the current; but much seems to depend on the type of discharge. In sputtering experiments, it is evident that for rapid deposition it is beneficial to use small (wire) electrodes and as large an induction coil as may be expedient.

(5) *The Fall of Potential at the Cathode.*—The volatilisation of the cathode is augmented by increasing the potential on the tube, and such control is most readily available by regulating the pressure of the gas. Sputtering is much more pronounced at low pressures than at high. The pressure can, however, be forced too low, and at the stage when the glass begins to phosphoresce, the disintegration falls off in a marked degree; this may be due to the fact that less current is then conveyed by the gas. During the process of sputtering the pressure usually falls, probably owing to absorption or trapping of the gas by the film of metal.

The results obtained by Granquist on the relation between the pressure and the disintegration of thin metal plates of gold, platinum, silver and copper are represented in Fig. 2. The current through the tube was about 2½ milliamperes. The large increase in

the sputtering as the pressure is lowered will be remarked. It is noteworthy that the curves for Pt and Au cross at a pressure of about 0.6 mm. Hg.

The potential difference that is applied to a discharge tube is not distributed evenly along its length. The greater part of the potential is used up close to the cathode; there is a gentle potential-gradient in the space between the electrodes; and the remaining fall of potential occurs close to the anode. The general type of distribution is shown diagrammatically in Fig. 3. Now the amount of sputtering depends on the cathode-fall of potential, and this increases as the pressure of the gas is lowered. The greater the cathode-drop of potential, the farther also are the particles projected. There is no deposition within the cathode dark-space.

It appears to be essential that the potential-fall at the cathode shall exceed a certain minimum value before the metal becomes ionised and disintegrates to any appreciable extent. It is interesting to note

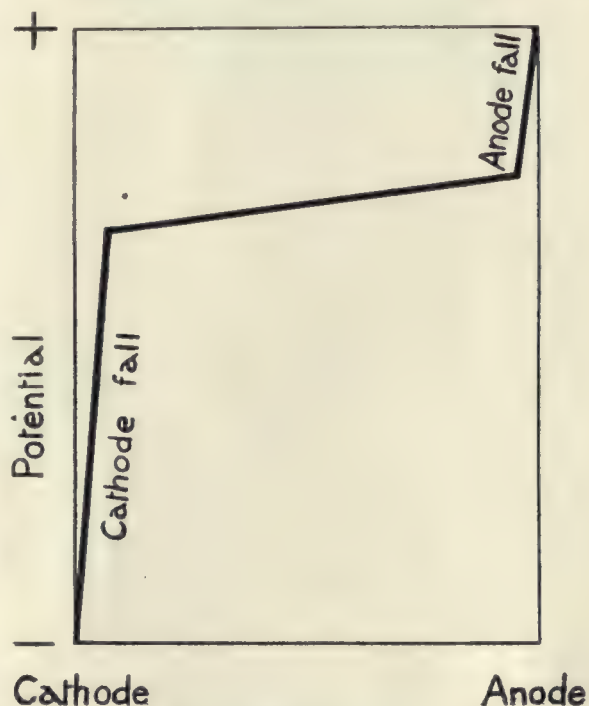


FIG. 3

that the presence of occluded hydrogen in the metal and its expulsion when the discharge passes, tends to lower the cathode-fall; this is unfavourable to disintegration. Holborn and Austin found that this critical disintegrating potential was about 500 volts for a number of metals in air at low pressure. The carbon filament of an electric lamp volatilises slowly at potentials as low as 50 volts; though the phenomena in this case are probably accentuated by thermal effects (see later).

The rate of disintegration is so markedly responsive to the potential-fall at the cathode that the difference of activity at the various parts of a cathode of irregular shape may sometimes be discerned. The potential attains a maximum at points and

edges, and accordingly it is at such places that the tendency for the metal to sputter predominates.

A discharge tube in the possession of the writer illustrates this feature very strikingly. The electrodes are cylinders made by bending thin sheet aluminium so that two opposite edges come nearly together. These cylinders were mounted symmetrically within the tube (Fig. 4) which was filled with helium—a gas somewhat favourable to



FIG. 4.—VACUUM TUBE WITH ALUMINIUM CYLINDERS.

the sputtering of aluminium, as has already been remarked. The pressure was not very low—about that which displays the helium spectrum to advantage—so that the tube ran easily, the dark space was small, and the potential applied was never great.

As Fig. 4 indicates, there is no trace of sputtering at the anode, but an examination of the tube near the cathode, shows that, while the glass facing the sides of the cylinder is untouched by any deposit, there is a brilliant black mirror on the glass immediately beyond each end of the cylinder. Each deposit has a fairly sharp outline; of the two, the deposit remote from the anode (*i.e.*, the side of the cathode from which the positively-charged canalstrahlen leave) is the more extensive.

Evidently the particles of aluminium are shot off exclusively from the region of the edges of the cylinder; elsewhere the potential attained was not high enough to cause the emission of metal. This is borne out by the fact that there is a narrow band of deposit on the glass parallel to and directly facing the slit where the two edges of the bent plate come together. These two edges did not quite meet, and the intervening space is reflected in the band of deposit which shows a streak of clear glass along the middle of its length. There is an extensive and ill-defined deposit on the inside of the aluminium tube opposite the slit. This is explained by the



FIG. 5.—ALUMINIUM DEPOSIT IN VACUUM TUBE.

positive potential of the inside of the sheet relative to that of the edges.

Fig. 5 is a photograph of the sputtered deposit on the glass with the cathode removed. Fig. 6 shows the outer surface of the cylindrical cathode, which has been flattened out for the purposes of the photograph; the extent of the stained active region round the edges is clearly discernible, and serves as an interesting illustration of the distribution of high potential electricity on a cylindrical conductor.

The writer has suggested that the deleterious blackening of X-ray bulbs might in great measure be prevented, at any rate with "soft" tubes (in which the potentials applied are not very great) by taking care to round off the edges of all the electrodes.

Practical Applications.—The method of cathodic deposition is now frequently employed in metallising surfaces and more particularly in the manufacture of metallic mirrors of all degrees of transparency. Almost any metal is readily deposited on glass or metal by this method of sputtering.

The chief essentials for success are (1) a pressure less than about 0.1 mm. mercury (a cathode dark-space of, say, 1 or 2 inches is suitable); and (2) an effective though not too powerful discharge. The body to be coated should be placed just outside the dark-space. The discharge tube, which may advantageously be filled with hydrogen, should be free from impurity. It is a useful, though not essential precaution to insert a rectifier or valve-tube of some kind in series so as to ensure a unidirectional current from the coil.

For the production of mirrors a disc cathode is convenient, or better, a brush of fine wires or a

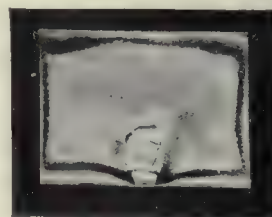


FIG. 6.—OUTER SURFACE OF ALUMINIUM CATHODE.

metallic grid of wires stretched parallel to the surface to be coated. Fawcett (*Phil. Mag.*, 1898) states that a grid of twisted gold and platinum wires yields a more homogeneous deposit than either metal alone. The receiving surface (previously carefully cleaned) should be put in connection with the anode. If the pressure is too high or the cathode too near the plate the films will not be uniform.

With short exposures, films as thin as 10^{-6} cm. and even less can readily be obtained by this method. Thick films of some metals are apt to peel unless very slowly deposited. Gold, silver, and iridium films can be obtained firm and adherent on glass, but in the case of platinum the films, though bright, are not strongly adherent; they can, however, by subsequently raising them to a dull red heat, be hardened sufficiently to resist abrasion; at the same time the electrical resistance falls. The soft and spongy nature of the untreated platinum deposit is probably due to its intense absorptive properties for gases.

In the case of gold, the very thinnest deposits are pink by transmitted light. As the deposition progresses, the colour becomes successively purple, violet, blue, and green. The green steadily darkens until the deposit assumes by reflected light the metallic lustre of gold. All the various forms change into the green film on heating; at the same

time the electrical resistance drops. R. W. Wood (*Phil. Mag.*, October, 1902) found that permanent records of these colours could be obtained by varying the degree of exhaustion and the distance of the receiving plate from the gold cathode.

This would seem to indicate that particles of different sizes are generated and are hurled different distances. With an alloy, the method might even afford a means of fractional "distillation" of the components. Crookes tried the experiment with brass in 1901, with negative results; but with an alloy of two metals markedly differing in sputtering properties, he met with more success. For example, Crookes mounted as cathode the purple-coloured alloy of gold and aluminium discovered by Roberts-Austen. On passing the discharge, Crookes found that while the gold was volatilised, the aluminium was not. The surface of the alloy accordingly changed to a dull white, which under the microscope showed irregular pitting, with no trace of crystalline structure.

The method of cathodic sputtering was used by Gehrcke and Leithäuser (1909) to platinise transparent gelatine replicas of diffraction gratings. The resulting reflecting gratings are described as comparable in brilliancy with the original Rowland gratings on speculum. R. W. Wood has similarly gilded replicas of his echelette gratings designed for light of long wave-length.

Sputtering has also been employed for plating and so rendering conducting quartz and glass fibres; for gilding mirrors; for half-silvering electroscope windows, Fabry and Perot interference plates and the like; and for the construction of high resistances. The method affords a means of making films of metals suitable for experiments on the transmission of polarised light, a fruitful field of inquiry to which a number of chemists have paid attention.

Size of the Particles.—Houllevigue (*Ann. Chem. Phys.*, 1909 and 1910) experimented with the deposit from a silver cathode in air at low pressure. By microscopic examination¹ and by measuring the

¹ It may be recalled that particles with diameters down to 8×10^{-7} cm. can be seen in the microscope; sizes down to 2×10^{-7} cm. are revealed

electrical resistance of the film he was able to infer the size of the individual particles, the two methods agreed in giving an average diameter of $(2 \text{ to } 6) \times 10^{-6}$ cm. This, which is of the same order as the particles in Bredig's colloidal solution of silver, is equivalent to a mass of about 10^{-15} grs., or some 10 million molecules of silver. A colloidal solution, it will be recalled, may be obtained by passing a high-tension discharge between metal electrodes under the surface of a liquid. The cathode sputters



FIG. 7.—PHOTOGRAPH OF PLATINUM DEPOSIT.

particles just as in a vacuum: the average diameter of the particles according to Zsigmondy is $(5 \text{ to } 8) \times 10^{-6}$ cm. in the case of silver.

Fig. 7 shows a microphotograph (taken from a paper by Stone, *Phy. Rev.*, 1905) of a platinum deposit formed in air under the rather high pressure of 0.2 mm. mercury. The magnification is about 2,000 diameters. The photograph reveals a number of perfectly spherical particles with diameters ranging from $(5 \text{ to } 9) \times 10^{-5}$ cm. Houllevigue has obtained similar photographs.

as circles of light in the ultramicroscope, while a particle with a diameter of 1×10^{-7} cm. cannot be seen at all.

(To be continued.)

RECENT PROGRESS IN THE STUDY OF INDUSTRIAL LEAD POISONING.

By C. A. KLEIN.

WITHIN the last few years lead poisoning has been carefully studied by a large number of workers, and their efforts have thrown much light on what was previously an indefinite and wholly unsatisfactory position. Lead poisoning is almost essentially a disease of occupation and the form observed in affected persons is rarely acute—the subacute and chronic type being most frequent. It is necessary to bear this point in mind during experimental work so that the results obtained should be of value.

There are three possible channels through which

lead can and does enter the body, viz., through the skin, the respiratory organs and the alimentary canal. Early investigators considered the alimentary canal to be the most serious source of infection, but recent work has not confirmed this view. The old idea was largely based on the observation that colic was an early and almost invariable symptom of lead poisoning, and thus it was considered that gastro-intestinal absorption preceded, and was responsible for this symptom.

The modern view is that colic is the result of

* * *

general infection, as it is found that colic is produced when absorption has been effected through only one of the other two channels.

A somewhat similar mistake was made as to absorption through the skin—wrist drop and localised paralysis being considered to indicate localised absorption. It has, however, been shown that these symptoms are but the result of general infection, and are produced by absorption of lead through channels other than the skin. Edinger considers that the muscles affected are those which are overworked, and that localised fatigue determines the affected area. Teleky's observations conclusively confirm this theory.

Absorption through the skin is now considered to be the least important mode of entry, as it has been found that workers engaged in occupations in which the chances of skin absorption are most favourable rarely suffer. Oliver¹ states that the eyelids of white-lead workers are often white with dust, and that some lead may be absorbed from the inner surface of the eyelid, but gives no evidence in support of the statement.

Of the other two sources it is considered that lung absorption is the most dangerous.

In 1891, Oliver in his Goulstonian lectures, indicated that lead dust suspended in the air might pass into the system through the lung, as well as into the stomach. He suggested that conversion into carbonate thence to soluble bicarbonate might take place in the lung, and the absorption of a soluble compound would then take place.

It was not until 1909 that Goadby commenced a series of investigations which have since supplied the key to the whole question and rendered possible a rational explanation of the efficiency of certain preventive measures which had in the interim been introduced.

In 1902, Legge² made an analysis of the type of processes responsible for lead poisoning in the manufacture of paints and colours in English factories, and found that 72% of the cases must be ascribed to dusty processes—an observation of fundamental importance, and one which has received emphatic confirmation by the decrease in cases consequent on the introduction of dust removal appliances.

As an instance, the poisoning in white-lead works since that date may be cited:—

REPORTED CASES.

1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
143	109	116	90	108	71	79	32	34	41	23

Similarly, in 1909, Legge³ reported a decrease of 50% in the cases recorded in ten years 1900—1909, clearly due to the introduction of dust removal appliances.

The researches of Goadby (some part of which

was in collaboration with Goodbody) are detailed in various publications, but have been collected together in a recently published work.⁴

The experiments are most exhaustive and constitute the most important contribution to the study of lead poisoning during recent years, and the writer of this article is indebted to the above work for much information.

Goadby selected cats for his experiments, as their behaviour under the influence of the poison is comparable with that of man, so that the observations are capable of direct interpretation. Some slight difference is found, but in all cases of difference a rational explanation is apparent. The selection of the animal is of considerable importance as all animals are not affected similarly, *e.g.*, the rat appears to be immune.

In his experiments, Goadby submitted cats to conditions whereby they received lead compounds either by inhalation or by swallowing, and at a very early stage some striking results were obtained which led to detailed investigation of many features of the problem. It was found that under certain conditions lead could be swallowed by the animal with no ill effects, but much smaller quantities of the same compound produced severe poisoning at an early stage when inhaled.

A few typical experiments may be quoted:—

Cats were fed for periods of eight, eighteen, and twenty-four months respectively (receiving on an average 0.8 gr. white-lead powder per day) without any ill effects being observed, whilst cats inhaling every third day a quantity of white-lead dust equal to about one-tenth (when calculated per day), exhibited symptoms of lead poisoning after twelve or less inhalations, and in two months died or had to be killed.

A further series of experiments was made in which the animals were treated exactly as above but received alcohol, in the form of 50 c.c. of port wine daily, and in these experiments striking proof of the predisposing effect of alcohol was forthcoming. An animal which had previously been fed on white-lead dust for eight months without ill effects showed symptoms of lead poisoning in one month when alcohol was added to its diet, and died in two months, whilst another fed daily on 0.8 gr. white-lead and 50 c.c. port wine died in thirty-eight days.

Similarly, in the inhalation series an animal receiving alcohol showed symptoms after four inhalations against twelve required in the case of a non-alcoholic animal.

Subcutaneous inoculation of 2.0 grs. white-lead resulted in death in twenty-three days even though the inoculation was only made once.

Details of many other experiments using varying lead compounds will be found in the work cited, and the foregoing have been taken as typical examples on which important conclusions have been based.

It is obvious from these results that in order to produce its most dangerous effects, lead must be submitted to contact with the intimate fluids of

¹ Bulletin of the Bureau of Labour, Washington, No. 95, 1911.

² Report on Manufacture of Paints, etc., 1905, Cd. 2466.

³ Report of Factory Inspector, 1909.

⁴ "Lead Poisoning and Lead Absorption." Legge and Goadby. Arnold, 1912.

the body, rather than with the fluids of the digestive tract. Subcutaneous inoculation is not a likely industrial risk, and apart from its support to the above conclusion it has little or no industrial importance.

Goadby considers that the relative importance of the two channels of infection may be expressed—

Respiratory tract : Gastro-intestinal system as

100 : 1

a complete reversal of previous ideas.

Under industrial conditions, the two modes of absorption depend respectively on the inhalation of dust-laden air and on lead products swallowed.

It was formerly considered that the bulk of the dust inhaled in dusty air was deposited and removed by contact with various wet membranes, etc., before the lung was reached, and that in the cleansing of these surfaces the deposited dust was swallowed and so entered the stomach. It has, however, been shown by Goadby that the bulk of the inhaled dust actually reaches the lung, and that entry into general circulation is effected through that organ. When it is remembered that the particles of dust are necessarily of very minute size (in order that they should remain in suspension), it is not difficult to imagine this to be the case. The presence of particles of carbon in the lungs of those living in cities, the colouration of sputum ejected by certain individuals on foggy days, and finally the well-defined deposit in the lungs of those engaged in certain dusty processes are all proof that solid particles can and do enter the lungs by inhalation of dust-laden air.

Lead has been detected in the blood returning from the lung of an animal subjected to lead dust,⁵ whilst Tanquerel and Stranski have produced lead poisoning experimentally by blowing lead dust through a tube inserted in a tracheotomy opening.

Legge and Goadby are of opinion that absorption in the lung is of a complicated character. From experimental evidence they are of opinion that the finer particles of lead compound which have gained access to the lungs are taken up by the phagocytes and by them transferred to the interior of the cells, and there by the normal action of the serum of the blood are carried into general circulation, whilst the remaining larger particles are brought into solution by the carbonic acid in the manner suggested by Oliver.

It is not to be supposed that absorption in the alimentary canal is unimportant, as might be indicated by the fact that animals were successfully maintained on lead compounds for lengthy periods, but the experiments indicate that gastro-intestinal absorption is by no means the most important source of poisoning.

The absorption of lead through the alimentary system is dependent on a large number of factors, and in this connection it is advisable here to raise a note of warning against the practice sometimes adopted in dealing with problems of this type.

Certain workers have viewed the solution of lead compounds in gastric juices as a problem of extreme

simplicity regardless of the peculiar local conditions necessarily governing and complicating such processes.

It is obviously not correct to consider the gastric juice to be strictly comparable with a pure solution of hydrochloric acid when one considers that both lactic and acetic acid are present in gastric juice and that undigested and semi-digested food are usually present in the stomach. The temperature of digestion is of importance, and experiments have shown that the solubility of lead compounds in gastric juice increases quite considerably when experiments are made at body temperature as against room temperature.

An instructive example of possible variation is shown by the experiments of Goadby, who has determined the solubility of various lead compounds in human gastric juice. He found lead sulphate to be as soluble as lead oxide and carbonate—an unexpected result, when the solubilities of these substances in 0.25% hydrochloric acid are considered.

The solution of lead compounds in the body fluids cannot be estimated from normal solubility considerations, and further work is necessary on this point. One factor presents some difficulty, viz., the relative quantities of the solvent and the lead compound to be examined. It is obvious that no definite or constant proportion can exist in the body, and therefore it is necessary to fix a purely arbitrary standard for comparative purposes. Bedson and Best⁶ have investigated the solution of lead compounds in various body fluids, e.g., human saliva, gastric juice of dog, etc.

The process of stomach digestion after about 15 minutes becomes acidic in character, and lead present may be converted into a soluble salt but is precipitated from the solution as an insoluble albuminate etc., if food is present. These organic lead salts have some interesting chemical properties, e.g., they are apparently able to resist the action of H_2S and do not blacken on exposure to this gas without preliminary and somewhat drastic treatment with mineral acids or alkalis.

The presence of food therefore is most important as influencing the precipitation of lead in an insoluble form, and this has been realised in the practice of giving milk to lead workers before they start work. Malnutrition alone is a predisposing influence. The insoluble salt is not absorbed in the stomach and it appears certain that absorption seldom if ever takes place in that organ.

On leaving the stomach semi-digested food with the lead salt passes into the small intestine and is there subjected to the action of pancreatic juice and bile. It has been shown that absorption of lead takes place almost entirely from the small intestine, but again the exact mechanism of absorption is not definitely understood.

Goadby has shown experimentally that a soluble lead salt may enter the portal vein from the small intestine in the absence of food. In addition to the digestive action of the pancreatic fluids on lead albuminate or peptonate there appears

⁵ Goadby. Report on Pottery Committee, Vol. II., p. 58.

⁶ Quoted by Oliver, Bull. Lab., loc. cit.

to be absorption by means of the phagocytes in a manner somewhat similar to that effected in the lungs.

Although possibly the action is similar the conditions are somewhat different. When lead enters the lung it is retained until taken into general circulation, but the intestine, under normal circumstances, does not retain its contents for lengthy periods, so that the chances of absorption are limited by a time factor. This emphasises the necessity of workers avoiding constipation.

The acidity of the semi-digested food entering the small intestine is neutralised and rendered alkaline by the pancreatic juice and bile, but towards the end of the small intestine acidity is reproduced so that here the production of soluble lead appears possible; at this stage sulphuretted hydrogen is produced by fermentation of the sulphur compounds present, and absorption becomes a question of mass action; if sulphuretted hydrogen is in excess no solution is effected; on the other hand, if there is a deficit, solution and absorption does take place. Goadby has noticed an apparent resistance in Italians, who are stated to eat large quantities of vegetables and particularly onions, and ascribes some of the resistance of these workers to the increased production of sulphuretted hydrogen in the intestine.

In certain works, tablets of sulphur or sodium sulphide are supplied to the workers with a similar object in view.

The production of sulphuretted hydrogen is responsible for the well-defined staining of the ileo-cæcal valve and the large intestine which takes place in cases of lead poisoning, and the fact that this staining is present in animals which have not received lead by the stomach gives a clue to the method of excretion of lead.

It is proved that the largest quantity of lead is excreted with the fæces and that it enters the large intestine from general circulation, so that lead absorbed from the small intestine is carried into circulation and finally passes into the large intestine thence being ejected.

Some lead is found in the urine, but Dixon Mann and others have shown that it is much less in quantity than that excreted by the fæces. The detection and estimation of lead in animal products

and organs is a difficult matter owing to the presence of organic matter which is in tremendous excess. In cases where death has been caused by lead poisoning, the organs frequently contain only an infinitesimal quantity of lead, and considerable experience is necessary in the analysis of such materials.

It appears possible to establish some kind of equilibrium between intake and output of lead from the body, and, further, there is some indication that by judicious treatment a type of resistance may be built up whereby this equilibrium may be established. The equilibrium is broken down under certain conditions of physiological derangement, or may not be established owing to inherent functional weakness. Such weaknesses must be considered as predisposing causes. Owing to the peculiar accumulative character of lead as a poison, temporary derangement at times brings into circulation an excessive quantity of lead so that ill effects are asserted without any increased intake of the poison.

The action of potassium iodide is an example of this; in some cases an administration of this drug has transformed a chronic case into acute owing to the drug, by solution, having brought into circulation an excessive quantity of lead from the various parts of the system in which it was stored.

In dealing with any problem of industrial hygiene it is necessary for research similar to the foregoing to be carried out, and now that the processes of lead absorption are more clearly understood and defined we may confidently look forward to an intelligent appreciation of the dangers attendant on the industries concerned.

In addition to physiological and chemical investigations there must be careful statistical work. An excellent example of the value of careful work in this direction, is shown in the previously quoted analyses by Legge of the processes responsible for lead poisoning, where he was able to show that dusty processes contributed 72% of the recorded cases, thereby at once indicating the lines on which reforms were necessary.

The object of this article is to bring to the notice of those not intimately interested in the question of lead poisoning a record of recent work on the subject, which has a general interest.

NOTES OF MEETINGS.

CHEMICAL SOCIETY.

May 1st and 15th, at 8.30 p.m. Ordinary Meetings.

* * *

SOCIETY OF CHEMICAL INDUSTRY.

London Section. May 5th, at 8 p.m.

* * *

THE ROYAL INSTITUTION.

May 1st, Annual Meeting, at 5 p.m.

May 5th, General Meeting, at 5 p.m.

May 10th and 17th, Mr. H. A. Humphrey, "Humphrey Internal Combustion Pumps," at 3 p.m.

May 20th and 27th, Professor T. B. Wood, M.A., "Production and Utilization of Wheat in England," at 3 p.m.

May 22nd, Professor W. J. Pope, F.R.S., "Molecular Architecture," at 3 p.m.

May 23rd, Professor S. P. Thompson, F.R.S., "The Secret of the Permanent Magnet," at 9 p.m.

May 24th and 31st, Professor E. Rutherford, "Radio-Activity," at 3 p.m.

May 29th, Professor W. J. Pope, F.R.S., "Chemistry in Space," at 3 p.m.

UNIVERSITIES AND COLLEGES.

THE ROYAL COLLEGE OF SCIENCE FOR IRELAND (FACULTY OF APPLIED CHEMISTRY).

By Professor GILBERT T. MORGAN, D.Sc., F.I.C., M.R.I.A., A.R.C.Sc.

THE new buildings of the Royal College of Science for Ireland are probably among the least known of the public edifices of Dublin, for, indeed, even the most observant visitor to the city might traverse Upper Merrion Street many times without noticing the insignificant *cul-de-sac* with forbidding palisade which at present constitutes the only main entrance to what has been designated by local enthusiasts, in no spirit of vain boasting, as the "Irish Charlottenburg." The writer of this article seldom enters the narrow doorway of the palisade without being reminded of Aladdin and his magician, for so out of keeping with its present somewhat dilapidated foreground is the new College, that its presence there suggests some process of enchantment rather than of natural development.

The College, a handsome white granite and Portland stone building in classic renaissance style, occupies three sides of a quadrangle which will, in the near future, be completed

by the erection of new Government offices, a plan involving the demolition of a row of tall old residential houses, now utilised as offices, which at present very effectually hide the College from the public gaze.

The old College was situated in St. Stephen's Green and housed in the building formerly occupied by its forerunner, the Museum of Irish Industry, an institution founded by the State in 1845 with the object of promoting "industrial science and education and the improvement of mining, metallurgy and mechanical and chemical manufactures in Ireland." This Museum possessed a staff of professors which included Dr. W. K. Sullivan and Monsieur Gages as teachers of chemistry, and public lectures in science were delivered, chiefly in the evening.

In 1864, a Select Committee of the House of

Commons recommended a reorganisation of the State aid given to science in Ireland, and it was held desirable that a college of science should be



THE MAIN ENTRANCE.

established. A Royal Commission, which included Sir Robert Kane, the Director of the Museum, and Professors Frankland, Hofmann, Huxley and Tyndall, was then appointed to advise as to the



ORGANIC LABORATORY.

constitution and staff of the College. The report of this Commission was issued in 1866, and a Treasury minute of January, 1867, brought the College of Science into existence with a small Government grant.

In the chemical division, the staff consisted of Dr. W. K. Sullivan, Professor of Chemistry, Mr. R. Galloway, Professor of Applied Chemistry, and Mr. W. Plunkett, Assistant Chemist. From the outset, courses of practical laboratory instruction formed an important and essential part of the College curriculum, a policy which was emphasised in the chemical section by the foundation of two chairs, one in theoretical and the other in practical chemistry. When Dr. Sullivan left the College in 1873 to succeed Sir Robert Kane, as President of Queen's College, Cork; the two courses were united in one chair, which was held until 1879 by Professor Galloway, who was then succeeded by Dr. (now Sir Walter) Hartley.

Under Professor Hartley's régime the chemical division became prominent among the foremost schools of chemistry in the United Kingdom, and in particular the chemical laboratory gained world-wide fame as a centre of spectroscopic investigation. The Professor and his collaborators applied the spectroscope with conspicuous success to many problems of pure and applied chemistry, ranging from the spectroscopic phenomena of the Bessemer converter to the ultra-violet absorption of organic compounds.

The list of associates of the College, extending over a period of forty years, shows that many students of the chemical division have distinguished themselves greatly in their scientific careers and now hold important positions in both the industrial and academic branches of the chemist's profession.

For more than thirty years the work of the College was pursued in its original home in St. Stephen's Green, but the gradual increase in the number of students, and the rapid development of scientific and technical education abroad, led to a demand for more adequate accommodation as regards space and for considerable extension in equipment and laboratory facilities. In 1899 a Committee appointed by the Science and Art Department reported favourably on a scheme for the erection of an enlarged college, and indicated the site now occupied by the new buildings. In 1900 the Royal College of Science was transferred from the administration of the Department of Science and Art to that of the newly constituted Department of Agriculture and Technical Instruction for Ireland. Until 1902 the chemical staff had consisted of the Professor, Assistant Chemist and Professor's Assistant, but now an increase was effected by the creation of a Lecturership in Organic Chemistry. Dr. F. G. Donnan, who was first appointed to this post, was succeeded, on his promotion to the

Chair of Physical Chemistry in the University of Liverpool, by Mr. A. O'Farrelly.

The design of the new College buildings was



PROFESSOR'S RESEARCH LABORATORY.

executed by Sir Aston Webb; the foundation-stone was laid by the late King Edward VII. in 1904, and the College was opened formally by his Majesty King George on July 8th, 1911.

The laboratories, lecture rooms and offices of the Faculty of Applied Chemistry occupy the upper ground floor of the main building and include a large lecture theatre, a smaller lecture room, three general laboratories, a laboratory of chemical technology, and a number of smaller laboratories for special purposes and research.

The large lecture theatre has a seating accommodation for about 200 persons, and is used not only for the larger classes in chemistry but also for conferences and public lectures. An adjacent suite of rooms is devoted to lecture preparations and to

organic laboratory, fitted with benches and leaden-topped preparation tables, is capable of holding sixteen students. For the purpose of ultimate organic analysis, Fletcher earthenware combustion furnaces are provided both in this laboratory and in a special room for furnace work. The three general laboratories are each fitted with stacks of steam ovens arranged so as to furnish the distilled water required by the workers in these rooms. Two main balance rooms are provided, one adjacent to the general laboratory and the other between the organic and mineral analysis laboratories. Prepara-



GENERAL LABORATORY.

the storage of apparatus and specimens illustrating important branches of industrial chemistry. It is hoped that these materials will form the nucleus of a teaching collection in chemical technology. The smaller lecture room is used for advanced classes in organic, physical and applied chemistry.

The general chemical laboratory is a lofty room 30 ft. high by about 70 ft. square, capable of accommodating 120 students. Here in the summer term the first-year students of all faculties, having completed introductory courses in mechanics and physics, take up the study of practical inorganic chemistry. This laboratory is equipped both for advanced and elementary work, and throughout the session it is attended by senior students for special courses and research. In addition there is another general laboratory for mineral analysis. The

tions and analytical processes requiring high pressures are carried out in a special room containing four wrought-iron enclosures for sealed tube furnaces, and in this room autoclaves are mounted for the execution of high-pressure work on a more extended scale. A system of vacuum, produced by a Lennox rotary pump, is laid on to all research laboratories, and for specially high vacua a Gaede pump is provided. Various forms of shaking and stirring apparatus are available for the research laboratories in all of which electric plugs are conveniently placed for the purpose of supplying the motive power.

The laboratory of chemical technology is fitted with a reverberatory furnace having a movable experimental hearth, a large drying oven, vacuum stills, filter presses, evaporating pans, wooden vats

fitted with mechanical stirrers and inlet and outlet pipes for steam and liquids, and crushing and grinding mills. The production of the highest temperatures is rendered possible by several electric furnaces of different types and sizes, whilst low temperature research is provided for by a liquid air plant.

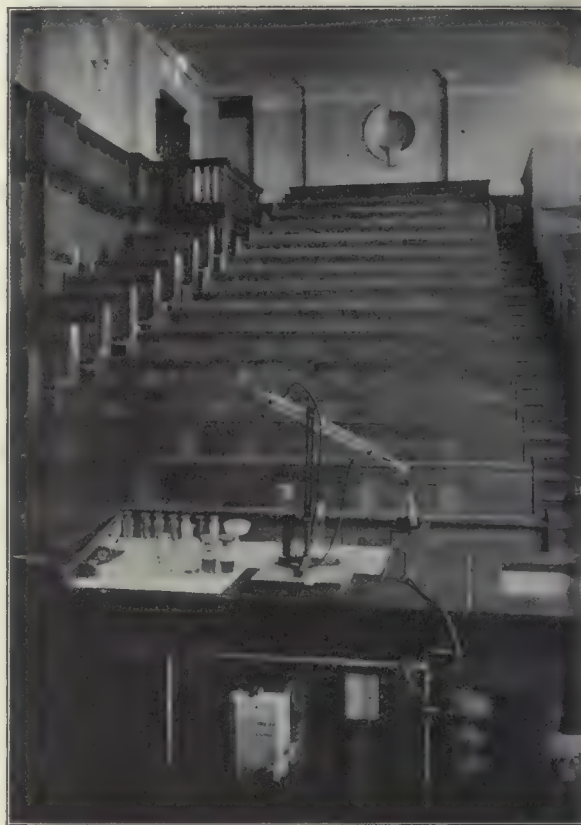
It need hardly be mentioned that a department presided over for so long by Sir Walter Hartley is particularly well equipped with appliances for spectroscopic research. The College tradition in this field of investigation is worthily maintained by Dr. J. H. Pollok. The chemical division possesses also an extensive collection of physico-chemical apparatus, the acquirement of which has been rendered possible by a generous equipment grant from the Treasury made at the outset of the new College's career. This apparatus includes the most modern forms of polarimeters, refractometers, pyrometers, thermostats, metallographic and photographic outfits, and a stock of silica ware and platinum vessels. The metallurgical laboratory and assay office are fitted with muffle furnaces, crucible moulds, sampling apparatus, assay balances and an outfit for electrolytic analysis with rotating electrodes. Smaller laboratories are provided for water and gas analysis.

Simple repairs to apparatus and plant can be speedily effected in the wood and metal workshop situated in the basement near the laboratory of chemical technology. The general ventilation of the College is effected by two 6-ft. electric fans placed under the roof and by high-pressure steam radiators fixed at the base of two vitiated air shafts arranged at either end of the building. The fume cupboards of the chemical department are specially ventilated by a separate system actuated by six small electric fans.

At the outset of the present session the curriculum for the Associateship of the College (A.R.C.Sc.I.) was expanded so as to cover a period of four sessions, and this extension of the courses has rendered it possible to give the students of the Faculty of Applied Chemistry a thorough grounding in other subjects besides chemistry. In the first session the time is devoted to mathematics, mechanics, physics, and inorganic chemistry in the order indicated. During the first term of the second session the chemical students are occupied with a more advanced course of physics and attend also a lecture course on the principles of organic chemistry. The requisite laboratory work is carried out in the second and third terms of this session, during which period lectures on physical and metallurgical chemistry are attended. The second-year students also continue the study of mathematics, mechanics, drawing and descriptive geometry, in order the better to understand the machinery of chemical manufacture and to make sketches and drawings to scale of chemical plant.

In the third session, associate students in chemistry begin to devote more time to their main subject. A course of lectures in general chemical technology affords a comprehensive survey of the

chief branches of applied chemistry. An advanced course of lectures in organic chemistry is delivered during this session. The growing importance to chemists of a practical knowledge of the transmission and utilisation of electrical energy has led to the inclusion at this stage of a combined lecture and laboratory course in electro-technology. A series of lessons in thermodynamics taken during this session is specially adapted to the needs of chemical students and is of great help to them in their reading of physical chemistry. The third-year students also attend during the third term a valuable combined lecture and laboratory course in



THE LECTURE THEATRE.

mineralogy and petrology. As at the Massachusetts Institute of Technology, a course in applied bacteriology forms a part of the curriculum taken by all students in the Faculty of Applied Chemistry. Apart from this very useful addition, the fourth session is devoted mainly to advanced practical work in physical, inorganic and organic chemistry. Special courses, varying from year to year, are given to fourth-year students on such subjects as the chemistry of the rarer elements, spectroscopic analysis, commercial gas analysis, metallurgy, applications of the electric furnace, photographic chemistry and the chemistry of the following arts: brewing and fermentation, wool, silk and cotton dyeing and the production of colouring matters, and synthetic drugs.

Senior students who have gained sufficient

experience in their preliminary studies are encouraged to take up problems requiring original investigation and the use of modern appliances for research with which the chemical division is well provided. During the current session, researches have been in progress bearing on such technological subjects as the distillation of wood and peat, an application of the electric furnace to the rapid analysis of alloys and the production of synthetic drugs and colouring matters.

A College library of 25,000 volumes, which includes the chief scientific publications, enables students to gain access to the literature of modern chemical research.

In addition to the full course in applied chemistry, short summer courses to teachers are given during July, and last summer about eighty teachers availed themselves of the facilities offered in the chemical department under the auspices of the Department of Agriculture and Technical Instruction.

Both in regard to the complete equipment of the chemical laboratories and to the generous inclusion in the full course of many important accessory subjects the students of applied chemistry enjoy exceptional advantages within the walls of their own College; and, moreover, the atmosphere of study and research resulting from the situation of the College with respect to other educational establishments in Dublin is too important a factor to be overlooked. It would be difficult in any other metropolis to find an arrangement of colleges, museums and libraries more congenial to the earnest student than that obtaining on the south side of the Liffey. Within the proverbial "stone's throw" one reaches the two Universities and several other collegiate institutions, the National Library, the Museum of Science and Art, the Natural History Museum, the Royal Irish Academy, the Royal Dublin Society, the National Gallery and School of Art, and numerous literary, artistic and scientific clubs and associations.

Already a spontaneous interchange of students is developing, and the process will probably become more prevalent in the future. Associates of the Royal College not infrequently commence or extend their studies either at the University of Dublin (Trinity College) or at the National University; and on the other hand, students and graduates of these Universities sometimes avail themselves of the laboratory accommodation afforded by the College in order to take up special courses or lines of research.

As its official title indicates, the College exists primarily for the training in applied science of Irish students, many of whom take their diploma in Agriculture; but sea-borne aspirants to the Associateship, either in this faculty or in those of Engineering and Applied Chemistry, are made very welcome and find within a convenient compass abundant opportunities for intellectual development and pleasant recreation.

Professor W. Gowland, F.R.S., will deliver the last of a series of four lectures on May 2nd, on "Recent Advances in the Metallurgy of Copper, Gold, Silver, and Lead," at the Old Royal College of Science Building, South Kensington.

PERSONAL AND OTHER NOTES.

(The Editor will be pleased to receive notices of appointments, etc., for publication in this column.)

SIR OLIVER LODGE has been appointed President of the British Association Meeting in succession to the late Sir William White.

The Chemical Trade Journal reports that the governing body of the Royal School of Mines, South Kensington, is about to appoint a new professor of metallurgy in succession to Professor Carlyle, who is retiring.

Since the recent developments in Professor Kennedy Duncan's scheme were noticed in our last issue he sends the further information that the scheme at the University of Pittsburg will take a still more definite form through the generosity of Messrs. A. W. and R. B. Mellon, who have given the sum of £90,000 towards the scheme. An Institute of Industrial Research and School of Specific Industries will be now definitely formed at the University. This will naturally permit of a material development in the present industrial research scheme.

At a meeting of the Council of the Paris University, held on April 7th, it was stated that an arrangement with the London University had been made by which French students from the Paris University will in future be able to take two courses of six months each at the London University, these terms to count for their examinations in France. English students may do the same at Paris University for their final examination in London.

THE Consolidated Goldfields of South Africa, Ltd., gold medal has been awarded to Mr. C. O. Bannister, A.R.S.M., for his paper on the "Theory of Blast Roasting of Galena," embodying the results of his researches on this subject, by the Council of the Institution of Mining and Metallurgy.

An International Congress on the Adulteration of Foods will be held at Ghent on August 1st, 2nd, and 3rd, 1913. The Honorary President is Henry Carton de Wiart, Minister of Justice, Brussels; the Presidents are:—Emile Braun, Burgmaster of Ghent; J. De Vos, Burgmaster of Anvers, Antwerp; M. Kleyer, Burgmaster of Liège. Among the members are the following names:—M. André, Inspector-General and Minister of the Interior at Brussels; Dr. G. Bruylants, Professor at the University of Louvain; Dr. Félix Daels, Professor at the University of Ghent; J. H. Delleur, Vice-President of the Commission on Milk; Dr. Moor, Rector of the University of Brussels; Dr. H. De Smet, Professor at the University of Brussels; Dr. Francotte, President of the Academy of Sciences; Dr. Armand Jorissen, Professor at the University of Liège.

Among the papers that are expected to be submitted for reading at the Annual General Meeting of the Iron and Steel Institute, on May 1st and 2nd, are the following:—"Critical Ranges of Pure Iron, with Special Reference to the Point A₂," by Professor H. C. H. Carpenter; "Influence of Metalloids on the Properties of Cast Iron," by H. I. Coe; "Influence of Silicon on the Corrosion of Cast Iron," by Dr. J. Newton Friend and C. W. Marshall; "Studies in the Cold Flow of Steel," by P. Longmuir; and "Production of Sound Steel by Lateral Compression of the Ingot whilst its Centre is Liquid," by B. Talbot.

MOLECULAR PHYSICS.

By J. A. CROWTHER, M.A. (Fellow of St. John's College, and Demonstrator in Physics in the Cavendish Laboratory, Cambridge.)

CHAPTER IV. (continued).

THE NEW METHOD OF ANALYSIS.

Thus if O (Fig. 10) represents the position on the plate of the undeflected rays, and OX, OY are the directions of the electric and magnetic deflec-

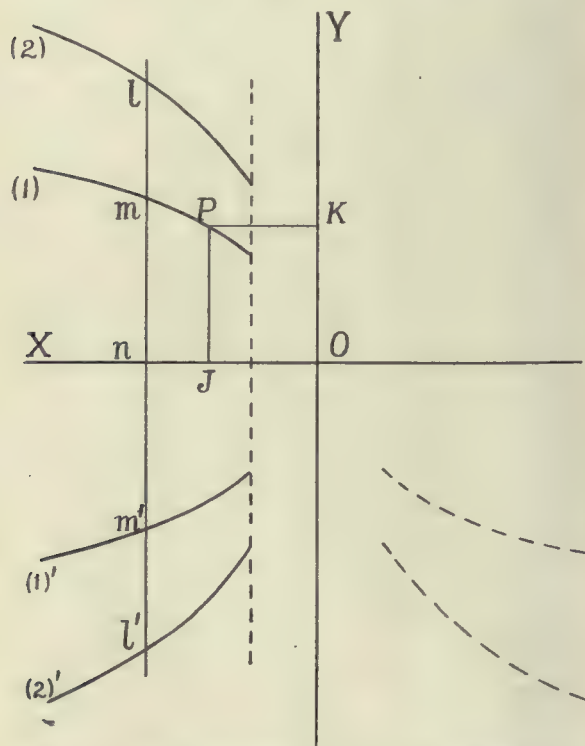


FIG. 10.—CHART SHOWING PATH OF CATHODE RAYS.

tions, the particle after passing through the two fields, will be deflected to some point P such that

$$PK = x = k_2 \frac{X.E}{mv^2} \quad \text{(electric deflection)} \quad (a)$$

$$PJ = y = k_1 \frac{H.E}{mv} \quad \text{(magnetic deflection)} \quad (b)$$

We see from these equations that

$$y/x = \left(\frac{k_1}{k_2} \frac{H}{X} \right) \cdot v \quad (c)$$

$$y^2/x = \left(\frac{k_1^2}{k_2} \frac{H^2}{X} \right) \frac{m}{E} \quad (d)$$

Thus, if the strengths of the two fields are kept the same throughout the experiment, all the quantities within the brackets will be constant. Thus, y/x will be a measure of the velocity of the deflected particle, while the ratio y^2/x will measure the ratio of the mass to the charge.

If all the particles were identical, and had the same velocity, the spot O would simply be shifted to the point P. As we have seen the velocities of

the particles vary considerably. The rays will therefore not be deflected to a single spot, even if their mass and charge are identical, but will be drawn out into a line or band. By equation (d) all the particles for which m/E is the same will, however, lie on some curve for which the value of y^2/x is constant; such a curve is known as a parabola.

If the particles emerging from the cathode consist of atoms of differing atomic weight, they will be sorted out into a series of parabolas one above the other, each curve corresponding to some definite value of m/E . Since the velocity which is proportional to y/x cannot exceed a certain value, these curves will not be complete, but will stop short at some definite distance from the axis OY. The appearance of the plate after exposure should therefore be somewhat as shown in the top left hand quadrant Fig. 10, where two such parabolas are shown.

To measure the curves, drop any perpendicular on OX, cutting the curves in l and m , and the axis in n . Then, from equation (b) it can be seen that

$$ln^2/mn^2 = y_2^2/y_1^2 = \left(\frac{m_2}{E_2} \right) \div \left(\frac{m_1}{E_1} \right)$$

since the value of x is the same for all points along the line lmn . Thus, if $E_1 = E_2$, that is to say, if the



FIG. 11.—LINES INDICATING PRESENCE OF MERCURY.

two particles carry the same charge, the ratio of the masses of the two sets of particles is simply equal to ln^2/mn^2 .

The line OX has no real existence on the plate, but the apparatus can be arranged so that the

direction of the deflections are parallel to the edges of the photographic plate, while the position of O is always marked by a very bright spot caused by rays which come through the cathode uncharged, and are therefore undeflected. A more accurate method is to reverse the field halfway through the exposure. The direction of the deflection is thus reversed, and symmetrical parabolas are formed on the opposite side of OX as shown in Fig. 10. The distance between the two



FIG. 12.—TYPICAL PHOTOGRAPH OF CATHODE RAYS.

branches of the same curve is then twice the distance of either from the line OX.

It will have been noted that the ratio of the squares on these ordinates does not give directly the ratio of the masses of the particles, but only the ratio of what we may term their electrochemical equivalents. Fortunately, however, the majority of the particles carry the single electronic charge e , while in any case the charge E on the positive particle cannot be more than a small integral multiple of this. Very little uncertainty is as a rule introduced from this cause, though it does occasionally arise. Mercury is the greatest offender in this respect, as mercury atoms carrying as many as eight charges are sometimes to be detected. Thus, five of the six parabolas on Fig. 11, which is reproduced from one of Prof. Thomson's photographs, are due to atoms of mercury, carrying respectively one, two, three, four, and eight charges. The latter line, though clear on the negative, is too faint to show up clearly in the reproduction.

The measurement and interpretation of the results can best be illustrated by an actual example. Fig. 12 represents a fairly typical photograph obtained with the apparatus. The gas in the discharge tube in this case was atmospheric nitrogen, that is to say, air from which the oxygen had been

extracted. Table III. contains the actual measurements made on this plate.

TABLE III.

Atmospheric nitrogen. Potential across discharge tube, 30,000 volts; current through magnet, 3.5 amperes; potential difference in electric field, 200 volts.

d m.m.	m/E .	Probable cause of line.	
7.2	200	Hg +	Mercury atom with single charge.
10.3	100	Hg ++	Mercury atom with two charges.
12.4	67	Hg +++	Mercury atom with three charges.
15.4	44	CO ₂ +	Molecule of carbon dioxide.
16.5	39	A +	Argon atom (40) with single charge.
19.4	28	N ₂ +	Nitrogen molecule with single charge.
23.1	20	Ne +	? Neon with single charge.
25.6	15.9	O +	Atom of oxygen with single charge.
27.6	14	N +	Nitrogen atom with single charge.
30.0	12	C +	Carbon atom with single charge.
38.7	7	N ++	Nitrogen atom with two charges.

The first column gives the distance of the different parabolas from the axis OX, measured along some common ordinate as explained above. The second column gives the value deduced from these figures for the relative masses of the particles, assuming that they all carry the same charge. If the charge carried is double or treble this value, the corresponding mass so obtained will be half, one-third and so on, of the actual mass of the particle. The standard line on this plate was the innermost one of all, which as its appearance shows, is due to mercury carrying a single charge. The mass of this particle is for convenience taken as being equal to its atomic weight (200).

Examining the table, it will be seen that the three inner parabolas represent particles having a value of m/E of 200, $\frac{1}{2}$ (200), and $\frac{1}{3}$ (200). They are due to mercury atoms having respectively, one, two, and three charges. Mercury vapour is always present in the tube unless special precautions are taken to exclude it, as it is used in the vacuum pumps attached to the apparatus. The next line is made by particles having a mass of 44; these are singly charged molecules of carbon dioxide; carbon compounds being usually present as impurities in small quantities.

The argon line (39) is the long bright parabola, immediately below the very thick bright line (28), due to molecules of nitrogen with a single positive charge. This, as might be expected, is the brightest line in the photograph. The parabola for which d is 23.1, is very faint on the reproduction. It probably represents Neon (20) though there is also the possibility that it is formed by argon atoms with a

double charge, as the argon line (40) is very bright. Our method does not enable us to distinguish between these alternatives.

The triplet of lines which follow is due to atoms of oxygen, nitrogen, and carbon. The last line on the plate, indicating a value 7 is the nitrogen atom with a double charge. The hydrogen line which is nearly always present, has been deflected entirely off the plate by the large magnetic field applied in order to separate the heavier constituents.

It will thus be seen that all the lines on our plate correspond to elements which we might expect to find present from the nature of the gas employed. There are no lines unexplained, and the values obtained



FIG. 13.—CATHODE RAYS.

for the relative masses of the particles correspond very closely to the atomic and molecular weights determined from chemical considerations.

The faint lines seen on Fig. 12 joining some of the parabolas to the origin, are due to the secondary effects which we have already mentioned. The mercury parabolas, however, as will be seen from the figure, do actually extend to within a very short distance of the origin. This is due to quite a different cause. Turning back to equation (a), it will be seen that the electric deflection is proportional to the charge E_1 carried by the particle in the electric field divided by $\frac{1}{2}mv^2$, the kinetic energy of the particle. We have seen that the maximum value of the latter is equal to $V \cdot E_2$, where V is the potential of the discharge, and E_2 the charge carried by the particle in the discharge tube. The minimum value of the electric deflection, that is to say, the nearest point to which the parabolas can extend will be proportional to E_1/E_2 and will thus be the same for all particles, whatever their mass and

charge if each particle carries the same charge in the tube as in the camera. Thus all the curves will stop short at a certain line drawn parallel to OY. This is well shown in Figs. 13 and 14.

If, however, a particle in the discharge tube having a double or treble charge, loses one or more of these extra charges before the electric field at MN is reached, the value of E_2/E_1 will be greater than unity, and the parabola will extend further towards the axis OY.

These extensions of the parabolas are very clearly shown in the three inner curves of Fig. 13, where an almost complete break occurs between the termination of the original parabola and its continuation by particles which have parted with one of their original charges. These three parabolas are due respectively to Mercury (200), Xenon (132), and Krypton (83). The two outer curves, representing Argon (40) and the Nitrogen molecule (28), end abruptly at the normal distance from OY.

The best example of the effect is, however, shown by the mercury lines in Fig. 11. The normal mercury atom in the discharge tube apparently carries a charge of $8e$, and approaches the cathode

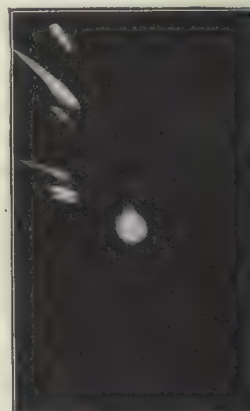


FIG. 14.—GAS EVOLVED FROM PLATINUM.

with an amount of energy equivalent to this. The innermost mercury parabola (Fig. 11) gives a value for the mass just 200 times that of the hydrogen atom. It is therefore due to a mercury atom carrying a unit charge, and having thus only one-eighth of the charge it carried in the discharge tube. The value of E_1/E_2 is thus $\frac{1}{8}$ and the parabola extends to one-eighth of the usual minimum distance from the vertical axis. The next line ($m = 100$) is due to atoms with two charges, and extends to one-quarter of the usual minimum distance, and so on, until the last parabola which corresponds to a mercury atom with eight charges (the same number as in the discharge), ends up at the usual distance from the axis.

This gradual shortening of the parabolas for the differently charged mercury atoms, is beautifully shown in Fig. 11, where the terminations of the five mercury parabolas can be seen to lie exactly on a straight line through the point O inclined at an angle to OY, as would be expected on the above theory.

(To be continued.)

CHEMICAL ENGINEERING.

A STANDARD METHOD FOR THE INVESTIGATION OF ATMOSPHERIC POLLUTION.

By JOHN B. C. KERSHAW, F.I.C.

AT the International Congress on Smoke Abatement, held in London on March 26th, 27th, and 28th, 1912, a Committee was appointed to draw up the details of a standard method of measurement for the smoke, dust and other impurities of the atmosphere. This Committee, of which Dr. W. N. Shaw, F.R.S., of the Meteorological Office, was appointed the Chairman, has held three meetings in London, and has published recently (in the form of a circular letter to the local authorities) some details of the method and apparatus that have been selected as most suitable for the work. The public health authorities in a large number of important towns—including Birmingham, Bradford, Hull and Newcastle—have already agreed to carry on observations with the apparatus and on the lines recommended by the Committee, and a large number of other towns are likely to join in the movement for a systematic and organised study of atmospheric pollution. The present article has been written for the purpose of bringing the standard method and apparatus to the notice of readers of this Journal, amongst whom there may be some who would be able and willing to co-operate in the observations. The method and apparatus chosen by the Committee is the simplest and most inexpensive of those that have been used for this work, and when once it has been erected at the place selected for the observations, it requires little attention.

The need for some standard method of making these observations is proved by the fact, that although measurements of the solid and suspended impurities of the atmosphere have been carried out recently by Rübner, Hahn and Liefmann in Germany; by Des Voeux and Vasey in London; by Cohen and Ruston in Leeds; and by Fyfe in Glasgow and other Scottish towns, the results obtained are valueless for comparative purposes, since these observers all used different apparatus and methods of work. The observations were carried out also for varying periods of time, in some cases for only a few weeks in the winter months of the year (as in Glasgow and Hamburg), in other cases for a whole year (as in Leeds and London). Since these observations

have not been continued, they represent isolated tests, and one is unable from a study of the figures obtained to state whether London has a cleaner atmosphere than Leeds or Glasgow, or whether any improvement is occurring in the cleanliness of the atmosphere of the individual cities. Continuous records of the soot and dust suspended in the atmosphere, taken in the various large centres of population and industry, by some standard method and form of apparatus are in fact required, before such questions as these can be answered.

The aim of the London Committee has been to provide these essential requisites for a scientific and systematic study of atmospheric pollution.

To those who fail to see any value in such a study, it may be pointed out that the soot and dust suspended in the atmosphere are harmful to the living organism in three distinct ways:

First, by diminishing the amount of sunlight which falls upon the earth, they directly lower the vitality of the human organism and its ability to resist disease. Cohen has shown that in Leeds from 25 to 40% of the sunlight was cut off by the smoke-laden atmosphere.

In the second place, the soot and dust suspended in the air of all manufacturing towns enters the lungs and chokes up the pores and cells of the lung tissue, thus hindering that rapid assimilation of oxygen by the blood and discharge of CO_2 and other waste products, which are essential to the maintenance of health.

Finally, direct sunlight and pure air are now recognised as the best of germicides. Smoke and dust, by diminishing the sunlight and defiling the air, therefore promote bacterial life, and are thus helpful in the propagation of all infectious diseases.

In view of these facts, the value of a standard method of measuring and recording the character and amount of atmospheric pollution in the air of all large towns and centres of manufacturing industry is indisputable, and the Committee which is behind this new movement, believe that in time the records which they have been instrumental in collecting of the soot- and dust-fall, will be equal in interest and importance to those of the rain-fall. The acceptance by Dr. W. N. Shaw, F.R.S., of the Chairmanship of the Committee, proves that the Meteorological Office authorities are in full sympathy with the aims and work of the new organisation.

Turning now to a consideration of the work of the Committee in selecting a standard form of apparatus for the observations, it was decided at

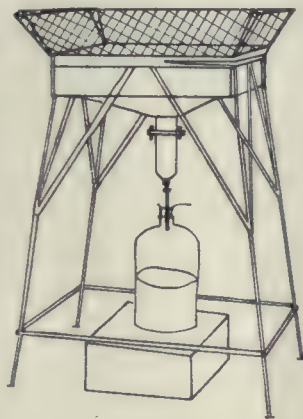


FIG. 1.—Lancet SOOT GAUGE.

the first meeting, that the method chosen must comply with the following conditions:—

(1) It must measure the actual amount of suspended matter in the air, not the amount relative to some other place.

(2) The impurity must be collected in a form which will permit an analysis to be made of it.

(3) The method and apparatus must be simple in principle and inexpensive in upkeep.

The following nine methods received careful consideration, before the Committee came to a final decision that methods 2 and 6 were the most suitable for use, under the conditions that would

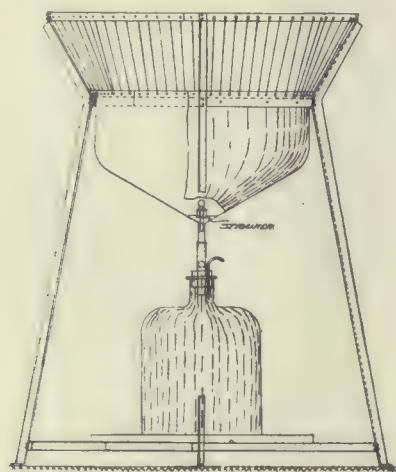


FIG. 2.—NEW STANDARD GAUGE (SECTIONAL).

obtain for the observations to be carried on under their auspices. It was decided also, for the present, to confine attention to the first and simpler of these two methods—namely, that known as the "Soot- and Dust-Gauge Method"—and used for the "*Lancet*" observations in London in the winter of 1910.

(1) *Filtration of a Measured Volume of Air through a Cotton-wool or Collodion-wool Filter, and Examination of the Deposit.*—This method has been used by Russell in London, and by Hahn in Germany, and can be made to give good results. With care, condition (1) can be fulfilled, and when collodion-wool is used, it can be made to satisfy condition (2). It requires, however, costly apparatus and considerable technical skill; and it possesses inherent defects if a colour scale be employed as the measure or gauge of the amount of deposit.

(2) *Collection of Rain-fall; Evaporation and Weighing of Residue.*—This method was used in the investigations carried out by Dr. Des Voeux and the "*Lancet*" in 1910, in order to obtain the soot-fall of London. It was also used by Professor Cohen in Leeds. The method does not, strictly speaking, give the amount of air-pollution, but the amount which falls on a given area (a) in rain, snow, etc., (b) during dry weather. (a) and (b) are not separated. The apparatus used for collection of the impurities may be very simple, and the technical work can be done at any laboratory. The examination of the residue may be confined to a separation of the soluble and insoluble constituents, or it may be

extended to the separation and identification of each constituent.

(3) *Aitken's Dust-counter.*—This was devised by John Aitken for counting the number of dust particles in the air. The method and apparatus satisfy condition (1) but not (2).

(4) *Exposure of Glass Plates to the Air for a specified Time, followed by Washing in Water, and Comparison of the Adherent Deposit that remains with Standard Colours.*—This method has been used by Professor Cohen in Leeds for catching the matter which will adhere to a glass plate—e.g., tarry soot. The thickness and colour of the deposit are likely to be affected, however, by the amount of tar present in the smoke of the city, and the method aims only at comparative results, and does not fulfil either condition (1) or (2).

(5) *Exposure of Glass Plates Coated with a thin film of drying Oil to the Atmosphere*—(a) Either for a fixed time, followed by measurement of the opacity by comparison with a calibrated scale; or (b) for such time as will produce a fixed opacity, and comparison of the time required with a calibrated time scale.

This method has been used by Cohen in Leeds, and by Liefmann in Hamburg, and it might possibly be made to fulfil conditions (1) and (2). It requires, however, elaborate apparatus and some technical skill, and it was decided that it was not suitable for application on a large scale, and under the conditions which will obtain for the Committee's observations.

(6) *The Air is Drawn at a Uniform and Measured Rate through a Filter-paper, the Degree of Blackness produced in a specified Time is then Measured.*—This method has been used by Rübner in Germany, and by Bailie Smith in Glasgow. It gives results which depend upon the colour of the matter caught, as well as upon its amount. Condition (2), however, would be fulfilled.

(7) *Measurement of the Transparency of a*

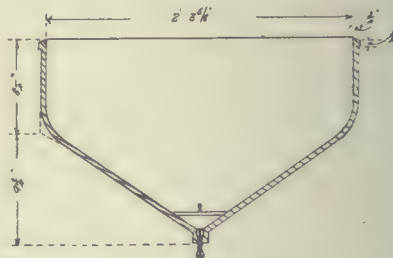


FIG. 3.—GAUGE VESSEL.

Column of Air of given Length when Illuminated by a Standard Light.—A modified form of this method has been used for observations of the density of smoke from chimneys in many towns. The method could probably be arranged to fulfil condition (1) by measuring the transparency of air holding in suspension known amounts of matter, but it would not fulfil condition (2).

(8) *The Rain-fall is caught and its Transparency is Compared with a Standard Scale of Values, made by adding Definite Quantities of Soot to Distilled*

Water.—This method is open to the same objections as the second method; neither does it fulfil condition (2). The results would depend also on the nature of the impurity, as well as on its quantity.

(9) *Dust-boxes are Exposed, having a Collection*

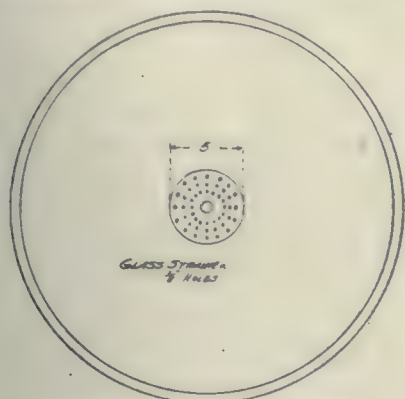


FIG. 4.—PLAN OF THE GAUGE.

Surface of one square foot.—These boxes have been used by Chief Inspector Fyfe in Glasgow and Aberdeen, and are simply a less accurate means of operating the second method.

Having selected a method, the Committee next devoted attention to the standardisation of the same, and the following specification for the Standard Soot- and Dust-Gauge has been drawn up, and cir-

Fig. 1 shows one of the soot-gauges used for the *Lancet* investigations in London in 1910, with the gauge vessel and bottle in position. Fig. 2 is a sectional elevation of the new standard gauge. Fig. 3 shows the gauge vessel alone, removed from its frame; and Fig. 4 is a plan of the gauge.

The stand is formed of four angle-iron legs riveted at the top to two iron rings, the lower of which must be of a suitable size to receive the gauge and support it. To the upper ring are attached galvanized iron wires of 14 S.W.G. These are fixed at their lower ends to a ring of $\frac{1}{16}$ -in. galvanized iron, riveted between the legs and the heavier ring, which supports the gauge vessel. A cage is thus formed, surrounding the gauge vessel, but open at the top, which prevents bird-droppings being mixed with the deposit in the gauge. A shelf of 1-in. pine is provided at the bottom, the boards being screwed to $1\frac{1}{2}$ ins. by 3-in. battens, which fit inside the iron supports riveted to the legs. All metal, except the gauge vessel, is galvanized iron.

The method of using this Soot- and Dust-Gauge, and of examining the deposit obtained in it, are now receiving the attention of the Committee, but the following preliminary Regulations have been issued regarding the choice of a suitable place of exposure, and the length of time between each successive observation:—

(1) All gauges are to be placed on the ground level, in an open space free from abnormal dust.

TABLE I.—LONDON'S COAL SMOKE AND DUST DEPOSITS.

	1	2	3	4	5	6	7	8	9	10
Observation Stations.	Litres of Rain.	Total Deposit.	Insol. Matters.	Soluble Matter.						Tons of Total Deposit per sq. mile.
				Total.	Fixed.	Volatile.	Sulphates. SO ₄ .	Ammonia. NH ₃ .	Chlorides. Cl.	
A.—Buckingham Gate, S.W. . .	201	71.9	46.3	25.6	13.3	12.3	6.0	5.0	5.7	500
B.—Horseferry Road, S.W. . .	192	60.3	33.5	26.8	12.3	14.5	5.9	5.1	4.1	420
C.—Old Street, E.C.	192	92.8	60.9	31.9	19.2	12.6	10.0	7.5	4.0	650
D.—Sutton in Surrey	210	27.9	8.3	19.5	8.7	10.8	0.89	0.34	2.1	195

NOTE.—All results in the above table—with the exception of those given in Col. 1 and Col. 10—represent the weight in grams of the deposit collected in the gauge during 12 months ending June 13th, 1911.

culated amongst the local authorities who have signified their wish to join in these observations.

The instrument consists of a circular open-topped gauge vessel, supported in a galvanized iron frame. This frame is provided with a shelf for carrying a bottle to contain the rain-water which enters the gauge. The gauge vessel is constructed of cast iron, enamelled with a vitreous insoluble enamel. It is of importance that the superficial area of the top of the vessel, included inside the sharp edge, should be constant in all vessels, thus assuring the same catchment area in each. To provide for this, the top edge of the vessel must be machined before enamelling. The catchment area is 4 sq. ft.

(2) The bottles containing the water and deposit are to be removed on the last day of each month, and thoroughly cleaned empty bottles are to be substituted.

(3) Before removing the bottles for analysis the gauge vessel is to be washed down with some of the water already collected, a brush of standard pattern being used to remove any adherent matter.

(4) A chemical analysis of the water and deposit is to be made by a standard method, particular attention being given to obtaining the relation between the quantity of tarry-oils present and the amount of free carbon.

A Sub-Committee is at present framing Rules for carrying out the chemical examination of the

deposit; these Rules will shortly be issued to all who have agreed to carry on observations with the standard apparatus. It is intended that the health committee of each city and local authority shall arrange for the examination of the deposit to be made locally, the earlier proposal to have all the bottles with their contents sent monthly to some Central Laboratory having been vetoed as impracticable.

In conclusion, a few figures may be given, showing the very remarkable preliminary results that have been obtained in London, Leeds, Glasgow and other Scotch towns, by application of this method of observation. Unfortunately, for the reasons given in the introduction to this article, these results cannot be used for comparative purposes. Des Voeux and Vasey used a metal funnel 2 ft. square at the top, Cohen a glass funnel of 6 ins. diameter, and Fyfe employed wooden boxes 1 ft. square at the top, and only 1 ft. deep. The method of examining the deposit was also different in each case. However, in spite of these discrepancies in the manner of applying the method, the results obtained are sufficiently interesting and startling to prove the need and value of the more systematic observations, which are about to be started under the auspices of the London Committee.

Professor Cohen's observations at Leeds—as reported in the Proceedings of the Smoke Abatement Conference, held at Manchester in November, 1911—gave the following figures:—

TONS PER SQUARE MILE PER ANNUM.

Station.		Suspended Matter.			
		Carbon.	Tar.	Ash.	Total.
Industrial.	Leeds Forge ..	189.6	31.4	318.0	539
	Hunslet ..	241.2	19.7	187.2	448
	Beeston Hill ..	87.1	42.6	202.5	332
	Philosophical				
	Hall	99.7	22.3	120.6	242
Residential.	Headingley ..	100.2	12.3	56.9	188
	Armley ..	98.0	9.7	61.7	169
	Woodhouse Moor	63.2	9.1	41.7	114
	Kirkstall ..	52.3	8.0	40.3	100
	Weetwood Lane	19.2	7.4	15.4	42
	Roundhay ..	7.7	4.0	14.0	25

The London observations were carried out from June, 1910, to June, 1911, at four stations situated respectively at Buckingham Gate, S.W., Horseferry Road, S.W., Old Street, E.C., and Sutton, in Surrey, on the borders of the Metropolitan Area. The water and solids collected by the soot- and dust-gauges were separated by filtration, and the soluble portion of the deposit was further examined in order to ascertain what proportion of it was volatile, and how much SO₂, NH₃ and Cl were present in the salts it contained. The figures obtained for the twelve months' observations are given in a table, published in the issue of the "*Lancet*" for January 6th, 1912.

Table 1 summarises the more important of these figures. The total deposit, it will be observed, ranges from 195 tons per sq. mile at Sutton to 650 tons in the East End of London, and if worked out on the basis of an average of 441 tons for the whole of the Metropolitan Area of 117 sq. miles, it represents an annual soot and dust fall of 51,597 tons over the Administrative County of London.

The average amount of air pollution in several towns and cities of Scotland has been investigated by Chief Inspector Fyfe, of Glasgow, and the results of his investigation are recorded in an interesting paper contributed to the Manchester Conference referred to above. The observations were only continual for the two winter months of the years 1910-1911, and therefore they cannot be compared with observations extending over 12 months. The results, however, are sufficiently valuable and interesting to be recorded here.

CWTs. PER ACRE PER ANNUM.

Town.	Mean Population. 1901-11.	Mineral Matter.	Carbonaceous Matter.	Hydrocarbons.	Total.
Bo'ness ..	10,086	1.35	0.83	0.09	2.27
Inverness ..	22,645	1.38	1.31	0.27	2.96
Stirling ..	19,801	2.52	2.50		5.02
Rutherglen	21,502	3.30	2.84	0.56	6.71
Ayr ..	30,841	2.68	4.35	0.25	7.28
Aberdeen ..	158,293	4.78	4.85	0.24	9.87
Port Glasgow	17,303	6.55	2.90	0.58	10.03
Pollokshaws	12,037	5.52	4.01	0.62	10.15
Clydebank ..	29,224	5.76	4.49	0.97	11.22
Greenock ..	72,025	5.80	5.08	0.82	11.70
Dundee ..	163,994	6.17	5.53	0.20	11.90
Paisley ..	81,920	5.91	7.26	0.62	13.79
Hamilton ..	35,709	9.25	4.37	0.60	14.22
Airdrie ..	23,338	8.61	4.81	0.93	14.35
Govan ..	85,969	7.65	6.69	0.65	14.99
Perth ..	34,923	3.58	13.34	0.39	17.31
Motherwell	35,761	11.47	6.83	0.97	19.27
Partick ..	60,573	11.37	6.98	1.19	19.54
Falkirk ..	31,424	12.99	5.77	0.86	19.62
Glasgow ..	780,028	27.03	13.54	1.04	41.61
Coatbridge	40,139	42.96	15.97	1.66	60.59

In order to convert these figures into tons per square mile the multiplying factor $\frac{640}{20}$ must be employed, and we then obtain totals for the annual soot- and dust-fall of Scotch towns ranging from 94 tons per annum at Inverness, 160 tons at Stirling, 320 tons at Port Glasgow, 480 tons at Govan, 627 tons at Falkirk, 1,331 tons at Glasgow, up to the enormous total of 1,939 tons at Coatbridge.

The Society of Public Analysts.—The next meeting will be held on May 7th at 8 p.m. Among the papers that will be read are the following:—"The Composition of Milk," by H. Droop Richmond; "A New Apparatus for Maintaining Constant Temperatures," by F. H. Dupre and P. V. Dupre; "On the Proportionate Determination of Coconut Oil and Palm Kernel Oil in Mixtures," by H. R. Burnett and Cecil Revis.

NEW METHODS OF ANALYSIS.

UNIFORM METHODS OF SUGAR ANALYSIS.

By FRANCIS V. DARBISHIRE, B.A., Ph.D., F.C.S.

IN 1907, Professor Herzfeld of Berlin made what I believe has remained the only attempt to perform a more thorough and more scientific chemical control of a sugar factory over a short period than is or can be carried out by the chemist who is in charge of the laboratory during the campaign.¹ In spite of the fact that the greatest care was taken to get good results the figures obtained by Herzfeld were most remarkable. The factory he fixed upon for his experiment was Elsdorf, in the Rhine Province, a factory founded in 1871 and working up about 1,000 tons of beetroots in 24 hours. It was chosen by him as the sugar was at that time, and is still, as a matter of fact, extracted from the roots by the ordinary diffusion process, as well as by the Steffen process. A very favourable opportunity was thus offered him of studying the working of both processes of extraction simultaneously.

The figures taken from his report read as follows:—

Diffusion Process:

Sugar delivered at the factory	15.67%	calculated on roots.
„ accounted for	15.48	„ „
Unknown Losses	— 0.19	

Steffen Process:

Sugar delivered at the factory	14.81%	calculated on roots.
„ accounted for	15.29	„ „
	+ 0.48	„ „

In other words, 0.48% more sugar was obtained at the end of the campaign than had actually entered the factory. For some time these results remained inexplicable, and as they were beyond experimental error and could not be accounted for by mistakes of sampling, this so-called Elsdorf report was somewhat severely criticised in several technical journals by well-known sugar chemists. Although the source of the inaccuracies was ultimately cleared up, Herzfeld had by that time come to the conclusion that the analytical methods would have to be carefully revised, and a committee made up of members of the Verein der Deutschen Zuckerindustrie was accordingly appointed with this end in view. The methods were all investigated in a very thorough manner; useless ones were discarded, and only those retained which were found to be sufficiently accurate for chemical control and at the same time reliable and rapid. The result of the labours of this committee was a pamphlet of thirty-two pages containing instructions for uniform analytical methods in raw sugar factories.²

¹ Z. V. (= Zeitschrift des Vereins der Deutschen Zuckerindustrie), Vol. 57, II., p. 1110 (1907).

² Anweisung für einheitliche Betriebsuntersuchungen in Rohzuckerfabriken. Berlin, 1910.

The polarimeter is one of the most valuable instruments the sugar chemist has; moreover, the rotation of sugar solutions is practically equivalent to that of quartz, which plays so important a part in the construction of polarimeters, and is not influenced to any appreciable extent by the temperature or the presence of foreign substances. The saccharimeter mostly in use on the Continent, outside France, is, as is well known, a half-shadow instrument with double wedge compensation, introduced by Schmidt and Haensch; in other words, one in which the rotation produced by the sugar is compensated by interposing a corresponding thickness of quartz of opposite rotatory power, to which a scale is attached on which the amount of sugar present is indicated. Continental saccharimeters are supplied with the so-called Ventzke scale, the history of which might interest the reader. In 1842, Ventzke, wishing to do without balances, which at that time he did not consider sufficiently convenient and handy, obtained his 100° mark by means of a normal solution instead of a normal weight.³ He defined a normal solution as an aqueous solution of pure sugar, having at 17.5° C., a specific gravity of 1.1. A column of such a solution 200 mm. in length placed in a polarimeter gave him his 100° mark; by dividing the whole distance from 0 to 100 into 100 equal parts on the scale, each division would be equivalent to 1% of sugar.

Solutions of impure samples having a specific gravity of 1.1 at 17.5° C. would, according to Ventzke, on being polarised, again indicate their percentage of sugar. This is not quite correct. Ventzke appears to have overlooked the fact that the specific gravity of certain soluble non-sugars is not identical with the specific gravity of pure sugar in solution. Since he had standardised his scale for pure sugar only, figures obtained by polarising other than pure sugar solutions would not indicate their true percentage of sugar. The specific gravity method of making up normal solutions was, out of these and other considerations soon abandoned, except in so far as the use of the scale division itself was concerned, as such a change would have meant supplying all apparatus with new scales. 100 gms. of a solution of specific gravity 1.1 at 17.5° C. was found to contain 26.048 gms. pure dry sugar; 26.048 was therefore adopted as the normal weight for all apparatus supplied with Ventzke scales, and retained for a number of years, as long in fact as Mohr flasks, introduced in 1855, were employed.⁴ It is well known that the difference between Mohr c.c. and true or metric c.c. lies in the fact that the former represent the space occupied by 100 gms. of distilled water weighed in air with brass weights at 17.5° C., whereas the latter or true c.c. represent the space occupied by 100 gms. of water at its maximum density or 4° C.; 1 Mohr c.c. is thus equivalent to 1.00234 metric c.c. In order to introduce uniformity with regard to the use of measuring flasks it was resolved at a meeting of public analysts held on February 26th, 1896 at

³ Journal für prakt. Chemie, Vol. 25, p. 84; Vol. 28, p. 111.

⁴ Chemische analytische Titrimethode, 1886, p. 44.

Berlin, to adopt true or metric c.c. only and to conduct all polarimetric work at 20° C. Recalculated on this basis the normal weight at 20° C. and for metric c.c. was found to be 26.0 gms.⁵

The National Physical Laboratory at Charlottenburg was also consulted on the subject. In a letter dated December 19th, 1898, to Professor Herzfeld, the Chairman of the International Committee for uniform methods of sugar analysis, it was pointed out that 26.01 was the correct value for the new normal weight and not 26.0. At the third meeting of the International Committee for uniform methods of sugar analysis, held in Paris on July 24th, 1900, it was finally resolved that for all apparatus supplied with Ventzke scales, the normal weight should be 26.0 gms., the normal temperature 20° C., and that metric c.c. should supersede Mohr c.c. The difference between 26.0 and 26.01 is so very slight, that it may be neglected.⁶

This matter was also taken note of and discussed in England. At a meeting of the chemists of the Beet Root Sugar Association, for example, held at Liverpool on May 8th, 1901, Mr. Macdonald, of Tate & Co., in the chair, it was resolved to adopt for all German instruments with Ventzke scales the normal weight of 26 gms.

To obtain the 100° mark, therefore, dissolve 26.0 gms. chemically pure, dry sugar, weighed in air with brass weights, in water, make up the solution to the mark in a flask marked with 100 metric c.c., with water at 20° C., and filter it. On polarising the solution in a tube 200 mm. in length in a room the temperature of which is kept at 20° C., the apparatus should indicate a reading of exactly 100 on the saccharimeter. Every degree of the scale will correspond to a sugar content in the solution under examination of 0.26 gms., or 1% of the amount weighed out. By dissolving 26.0 gms. of any sugar sample, and polarising it under precisely similar conditions, the number indicated on the scale will give direct without any further calculation the percentage of pure dry sugar in the sample.

The method made use of by Herzfeld for his investigations at Elsdorf was the so-called Sachs-le Docte cold-water digestion method. Methods of estimating the optical rotation of sugar solutions, may be arranged in three classes: namely, methods based on the process of expression, of extraction and of digestion.

The expression method consists of polarising the juice expressed from the pulp of sugar beets, etc., by means of powerful hydraulic presses and multiplying the result by the juice factor 0.95. In the seventies, this method was in common use. However, it was recognised at an early date, that this method was insufficient and lacking in accuracy. Scheibler, in 1878, first brought into practice a method of extracting with alcohol, in preference to the indirect analysis.⁷ It was modified by Sickel.⁸ Pellet entered upon a vigorous campaign against alcoholic, and in favour of aqueous extraction, for

which he claimed equal reliability.⁹ Numerous other modifications in favour of aqueous digestion were proposed, and in 1896, Krüger,¹⁰ and in 1906, Sachs and le Docte¹¹ devised methods now known by their respective names; they are based on cold-water digestion, and therefore require pulp of extreme fineness. It would be as well to remind the reader briefly that Krüger does without an actual normal weight, by merely diluting the weight of pulp with lead-water in the proportion of 1 to 3. Sachs-le Docte dilutes the normal weight of pulp to 200 c.c. by mixing with 177 c.c. lead-water; whereas Pellet in his hot-water digestion, employs 26 gms. of pulp, and makes up the solution to 200.6 c.c. As an example of an alcoholic digestion method that first introduced by Rapp-Degener in 1882,¹² might be mentioned, in which the double normal weight is digested for 20 minutes with 90% alcohol in a flask marked with 200.2 c.c.

The pamphlet contains a number of official methods which have now been adopted in German sugar factories, and which I also made use of while acting as chemist at Wendessen in Brunswick, during the last campaign.

One of these, the so-called hot-water digestion method, is new; it may therefore be stated in detail. It is a modification, suggested by Herzfeld, of the Sachs-le Docte method.¹³ Herzfeld's method of operation requires a number of metallic weighing dishes, bent in the form of troughs, and an equal number of metallic cans, with well-fitting lids; the weighing troughs are all equal in weight, so that the same counter-weight does service for them all. 26 gms. of the pulp are weighed into one of the troughs, trough and pulp slipped into one of the cans, and 177 c.c. lead acetate water added; after firmly securing the lid in its place the whole is well shaken. When the pulp is very fine filtration and polarisation can be performed without delay. If the pulp is coarse, or if for any particular reason hot digestion be preferred, the can is allowed to remain in a water bath previously heated to 75–80° C. for about 30 minutes, cooled down to normal temperature by placing it in cold water, or holding it in running water; the contents are then filtered and polarised in a 200 mm. tube. This method is used for the analysis of fresh slices, exhausted and pressed slices, except that 60 gms. of exhausted and pressed slices are taken instead of only 26 gms.

It will be necessary to make clear the meaning of the use of 177 c.c. of lead acetate solution. F. Sachs arrived at it from the following theoretical considerations. The beetroot pulp contains on an average 4.75% marc or insoluble cellular matter, and 95.25% juice. Twenty-six gms. therefore contain 24.8% juice, hence 175.2 gms. of water would have to be added to these 24.8 gms. in order to make the volume to 200. Sachs further takes the sugar contents of beetroots as lying between 12 and 17%, the corresponding purity coefficient

⁵ Z. V., Vol. 46, I., p. 180 (1896).

⁶ Z. V., Vol. 50, I., p. 357 (1900).

⁷ Neue Zeitschrift, Vol. 2, pp. 1, 17, 287; Vol. 3, p. 242.

⁸ Neue Zeitschrift, Vol. 2, p. 692.

⁹ D. Z. I. (= Deutsche Zuckerindustrie), 1888, p. 1229; 1889, p. 531.

¹⁰ D. Z. I., 1896, p. 2434.

¹¹ Z. V., Vol. 56, II., p. 924 (1906); *Sucrerie Belge*, Oct. 1908.

¹² Z. V., Vol. 32, pp. 514 and 786 (1882).

¹³ Z. V., Vol. 59, II., p. 633 (1909).

lying between 84.7 and 89.3; from these figures, he calculates an average of 23.1 c.c. juice in 26 gms. beet pulp, to which an addition of 176.9 c.c. or 177 c.c. of water would be necessary to bring up the volume to 200 c.c.

A very rapid and fairly accurate method of analysing exhausted beet slices, consists in expressing the juice by a powerful hand-press, filling up to the 100 c.c. mark in a flask marked 100-110, adding lead acetate solution up to the 110 mark, shaking, filtering, polarising and calculating the approximate percentage of sugar from the Soleil-Ventzke table, or by multiplying the rotation observed by 0.28. This indirect method is of great advantage for daily control work, as it furnishes the chemist with the means of at any moment informing the overseer of the battery whether the exhaustion of the slices is as complete as desired. Waste water, *i.e.*, the amount of juice to be drawn from the diffusors when the battery has to be emptied, is also analysed by the 110 c.c. volume method. The sugar content of exhausted slices is not allowed to exceed 0.5%, and that of the waste water 0.2% of sugar.

For very accurate examination or research, the best method is, after all, alcoholic extraction. It is not, however, suitable to rapid technical work during a sugar campaign on account of the loss of time it gives rise to. Herzfeld, in 1909, introduced a modification by the use of which the time taken in carrying out the analysis is considerably diminished.¹⁴ This new method, the most important feature of which is alcoholic digestion followed by extraction, is equally applicable to the analysis of fresh slices, exhausted and sugar slices, also roots. The normal weight of beetroot pulp or the half normal weight of dried and Steffen slices is transferred to a flask of about 100 c.c. capacity, half filled with 90% alcohol (60% in the case of dried and sugar slices). It is then clarified with 3 to 5 c.c. of lead solution, and digested for 10 to 15 minutes, with a reflux condenser attached to the flask, and transferred to an extraction apparatus, and extracted for about 2 to 3 hours at a slightly reduced pressure. The contents of the flask are cooled to 20° C., the volume completed to 100 c.c., shaken, filtered, and the polarisation read in the usual way but in a 400 mm. tube.

Dry matter is in all cases determined by drying 3 to 5 gms. in a special oven at a final temperature of 105 to 110° C., till after a further heating of 2 to 3 hours, the loss is less than 0.1%. Moisture in massecuites, syrups, and other liquid sugar products, is also determined by this method; they are, however, first intimately mixed with pure quartz sand.

Raw and thin juices are analysed by the 110 c.c. method already described; the degrees Brix are obtained with an hydrometer at 20° C., and the coefficient of purity calculated with the help of Schmitz's tables. Or the normal weight is clarified with a few c.c. of lead water, and the volume made up to the 100 c.c. mark and polarised. This last method is uniformly applied to more concentrated solutions, such as thick juice. The purity is then

obtained by dividing the percentage of sugar by the Brix degrees and multiplying by 100.

The men in charge of the filter presses are provided with so-called wash water or sweet water spindles, graduated from 0 to 5%, with instructions to continue washing the filter press cake until the water indicates 2% of sugar. It is very important however, for the chemist to be able to determine whether the work is being properly conducted or not. This he does by analysing the cake itself. The official method consists in treating 53 gms. with 177 c.c. of a 10% solution of ammonium nitrate. During the campaign, 1912-13, at Wendessen, much importance was attached to exhausting the cake of its sugar as far as possible, since if left in the cake it is lost. It is hardly possible in practice to remove every trace of sugar, and the average of my analyses for the whole season of 10 weeks was 1.4% sugar, which was, however, quite satisfactory.

The last six pages of the pamphlet give very precise directions for the analysis of raw sugar as adopted by the Institute of Sugar Industry at Berlin; such as preparation of the sample for analysis, determination of the percentage of sugar, ash and moisture, its invert sugar contents and alkalinity. It is not always easy to carry out the regulations during a campaign where much work is being done, unless the factory laboratory has special facilities for doing so. Take, for example, the instructions with regard to uniform temperature, on page 27: "When the volume of the liquid has been made up to the 100 c.c. mark, it is well mixed for some time and placed in the polarising room. This room into which all necessary apparatus and flasks have been put beforehand, is brought to a temperature of 20° C. for at least two hours before filtration is to be begun, and this temperature kept constant without interruption, so that the polarimeter, as well as funnels and cylinders required for filtering the sugar solution, also polarising tubes, all possess the exact temperature of 20° C."

INSTITUTE OF CHEMISTRY.

Pass List: March—April Examinations, 1913.—Of 11 Candidates who presented themselves for the Intermediate Examination of the Institute, 7 passed: J. D. S. Bramer, L. F. le Brocq, B.Sc. (Lond.), L. Davis, B.Sc. (Lond.), G. A. Stokes, S. H. Stroud, H. Trickett, and E. G. G. Wheeler. Of 25 Candidates who presented themselves for the Final Examination, 14 passed. In the Branch of Mineral Chemistry: S. C. Bate, B.Sc. (Lond.), F. G. Crosse, and S. G. Greene; in the Branch of Metallurgical Chemistry: E. Marsden; in the Branch of Organic Chemistry: W. F. Hollely, T. S. Jones, B.Sc. (Lond.), H. Lambourne, B.Sc. (Lond.), D. H. Peacock, B.Sc. (Lond.), B.A. (Cantab.), and F. Sproxton, B.Sc. (Lond.); in the Branch of the Chemistry of Food and Drugs, and of Water: A. L. Davidson, R. E. Griffiths, B.Sc. (Lond.), F. W. Hoyland, W. G. Saunders, and W. A. Storey.

The Biochemical Society.—The next meeting will be held in the Physiological Laboratory, Cambridge, on May 10th, at 4 p.m.

¹⁴ *Z. V.*, Vol. 59, II., p. 637 (1909).

REVIEWS OF BOOKS.

"CELLULOID: ITS MANUFACTURE, APPLICATIONS, AND SUBSTITUTES." By Masselon, Roberts and Gillard. Translated from French by HERBERT H. HODGSON. CHARLES GRIFFIN & CO., LTD., London, 1912. Pages 353 + vii, including Index. Divided into III. Parts and XXXII. Chapters, with 7 Plates and other Illustrations. Price 25/- net.

ALTHOUGH this work is not such an ambitious one as that published by Worden on the nitro-cellulose industry, yet within its province it deals in quite a remarkable manner with the preparation of celluloid products. The chapters dealing with the nitration of celluloid, both from the study of the nitration bath, and then from the point of view of commercial nitration processes, give a very good idea of theory and actual methods employed.

The particulars given concerning the bleaching, drying, steeping and staining of nitrocellulose are equally good. The sections dealing with rolling, compression, cutting and dressing, utilisation of waste, and the general organisation of a celluloid works, are also well done. The second part of the book is devoted to actual applications of celluloid, in practice, and working particulars are given for the manufacture of solid and hollow articles, celluloid linen, phonographic cylinders, beads, buttons, etc. The use of celluloid in photography is also noticed at some length.

Part III. is of special interest at the moment, as it deals with non-inflammable celluloids and substitutes, including the manufacture of cellulose acetates, and mixed acetates, and the use of viscose, casein, and other substitutes.

The book is well translated, and contains a large number of illustrations of machinery, and apparatus employed, and it may certainly be recommended to both the manufacturer and the student.

"L'HISTOIRE DE LA CHIMIE." By A. Colson. A. HERMANN ET FILS, Paris, 1910. Pages 130, including Index and Conclusion. Chapters X. Price 3 francs.

This work deals with the history of the developments of chemistry since the time of Lavoisier. Starting with the work of Scheele, and Chevreul, and that of Dumas and Peligot in 1835, the author passes to the work on the tetravalence of carbon, Kékulé's work on molecular constitution, and the work of Pasteur. Succeeding chapters deal with the practical methods adopted in the advance of chemical technique, the action of catalysers, and the work of later investigators, including that of Rutherford, Ramsay, and Crookes. The following chapters deal with such subjects as that of the application of mathematics to chemical problems, thermo and physical chemistry. The author's method of treatment is one which will appeal to those interested in the historical side of chemistry.

"THE PLANT ALKALOIDS." By T. A. Henry. J. and A. CHURCHILL, London, 1913. Pages 466 + vi, including Appendix and Index. Chapters IX. Price 18/- net.

For some years past an up-to-date text book on this subject has been required, and this work is calculated to meet the requirements of those who are interested in the identification and preparation of plant alkaloids. The groups as they occur in nature are dealt with in satisfactory sequence, and an appendix brings recent work on alkaloids right up to the time of publication. Dr. Henry's position gives him special qualifications for dealing with this subject, and he has followed up the main idea of the book in a very satisfactory manner. As a result the work forms a standard reference book to the general work which has been done on this subject in the past, and is likely to remain so for some years to come.

"A DICTIONARY OF APPLIED CHEMISTRY." By Sir Edward Thorpe. Vol. III., GR-OILS. LONGMANS, GREEN & CO., London, 1912. Revised and Enlarged. Pages 789 + viii. Numerous Illustrations. Price 45/- net.

The third volume of this important dictionary fully maintains the high level set up in the preceding volumes, both as regards standing of the contributors and the articles themselves. Among the latter those on artificial indigo, the lactones, lakes, liquefaction of gas, matches, naphthalene derivatives, nitrogen, and metallography may be mentioned.

The article on hydrogen possesses special interest at the present time, and possibly might have been extended so far as its applications are concerned. In this respect Caro's recent method of preparation does not seem to have been mentioned, although it has apparently been adopted by the Badische Company in connection with the manufacture of synthetic ammonia.

The articles generally are of such a high standard that the ones mentioned have only been selected for special notice on account of their special interest at the moment.

"THE ELEMENTS OF QUALITATIVE CHEMICAL ANALYSIS." By Julius Stieglitz. The CENTURY COMPANY, New York, 1912. Vol. I., Parts I. and II. Theory. Pages 312 + viii, including Index. Chapters XVI. Price \$1.40. Vol. II., Parts III. and IV. Laboratory Manual. Pages 151 + iv, including Appendix and Index. Sections VIII. Price \$1.20.

This work, which emanates from the University of Chicago, is divided into two volumes, the first of which deals with theory, and discusses osmotic pressure, the theory of solutions, ionisation, chemical and physical equilibria, hydrolysis, etc., and the second volume deals with the qualitative separation of metals, acids, etc. It is a satisfactory text book for the advanced student, for whose use it is obviously prepared.

BOOKS RECEIVED.

"**The Chemistry of Dyeing**," by John K. Wood. Gurney & Jackson, London, 1913. Pages 79 + II, including Index and Bibliography. Sections III. Price 1/6 net.

"**Laboratory Text Book of Chemistry**," Part I., by V. Seymour Bryant. J. & A. Churchill, London, 1913. Pages 246 + vi. Chapters IX. Price 4/- net.

"**Allen's Commercial Organic Analysis**," Vol. VII. Alkaloids, Glucosides, Animal Basis, Animal Acids and Cyanides. Edited by W. A. Davis and S. S. Sadtler. Contributors: W. A. Davis, E. Frankland Armstrong, G. C. Jones, A. E. Taylor, G. Barger, J. A. Mandel, and Herbert Philipp. J. & A. Churchill, London, 1913. Pages 563 + ix., including Index. Price 21/- net.

"**Dairy Technology**," by C. Larsen and W. White. Chapman & Hall, Ltd., London, 1913. Pages 298 + xiii., including Index. Chapters XXXII., with 48 Illustrations. Price 6/6 net.

"**Lectures on Chemistry in Gas-Works**," by W. J. A. Butterfield. Published by the Institute of Chemistry, 1913. Pages 71, with 6 Illustrations. Price 2/6 for non-members.

ENGINEERING NOTES.

By ROLAND J. DUNDERDALE, B.A. (CAMB.), A.M.I.C.E.

Boiler Incrustation.

In the issue of *Engineering* for March 14th a new method of removing scale from the shells and tubes of boilers was noticed, and, in the following issue, a short letter from Messrs. Lassen and Hjort, took exception to it, and stated that percussion, chipping and heat were all obsolete and bad methods of removing scale.

The best results in practice lie somewhere between these two conditions of treatment, though Messrs. Lassen and Hjort's statement is one with which no one will quarrel.

The fact is that a great many boiler waters cannot be completely softened by external chemical treatment, the end aimed at by Messrs. Lassen and Hjort and several other reputable makers of sound and useful water-softening plant.

Hence, unless very close attention is paid to the concentration in the boiler after softening, a slight scale is bound to form in time, and this, if it reaches any thickness, can only be satisfactorily removed by turbine or hand chipping. It may, however, be said in conclusion, that a great deal of money is still wasted on the fuel bill in this country through inadequate external softening, and it may be further remarked, that as most of the essential parts of a water softener cannot now be patent covered, those using at all hard waters would be well advised to erect such plant, if they do not possess one, or apply for a complete one to some competent maker.

Professor P. F. Frankland's Speech.

The above speech on the "Integration of Knowledge" at the Chemical Society's dinner in March appears to the writer to be of much more importance than speeches in general terms on general subjects usually are.

Looked at from the purely engineering side, the amount of time and money wasted in going over ground already turned and rendered fruitful, which might thus conceivably be saved, is simply appalling.

Many quite able engineers in chemical factories have to spend considerable time in rendering the plant up-to-date and efficient, or erecting such plant on a basis of entirely their own knowledge and experience, when, with properly "integrated knowledge" available, time in alteration

might be saved, or a new and suitable plant found almost immediately.

At present, unfortunately, the most fruitful source of ideas and information is the catalogue of a firm making somewhat similar plant. But these catalogues are, of course, filled with very special pleading, and apt to bias the reader, if well written, in favour of some special plant; whereas the recorded views of some engineer or chemist in charge of similar plant might save time and give a far more unbiassed view of the requirements.

Superheating and Pre-heating.

On Friday, March 14th, a long paper treating on the above subject from a locomotive standpoint was read before the Institution of Mechanical Engineers. At first sight this may not seem closely connected with chemical engineering, but a little consideration will show that one of the most constant and fruitful sources of saving in a chemical factory is the correct and suitable utilisation of waste heat from various plants or processes. The paper is full of valuable experience and data, and should be of great help in considerations of this kind. One or two points stand out for the consideration of the chemical engineer; while superheated steam is almost always economical *qua* steam, it cannot be applied offhand to old engines and machinery, owing to lubricating and other difficulties; also hot waste gases can now be utilised to much greater advantage than formerly on the principle underlying the Bonecourt boiler.

FINANCIAL NOTES.

The Badische Anilin und Soda Fabrik, of Ludwigshafen, aniline dye manufacturers, show net profits for the past year of 15,164,678 M; a gain of 2,767,275 M. over the previous year's working. It is proposed to pay a dividend of 28% (as against 25% as stated in our last issue), and to carry the sum of 2,000,000 M. to the special reserve.

At the annual general meeting of Lever Brothers, Ltd., held last month, the report showed a slight advance during the year 1912, as will be seen from the appended table:—

	1912.	1911.
Available balance ..	£779,403	£720,749
To repairs and renewals ..	£54,294	£53,980
To depreciation ..	£66,843	£57,686
To insurance reserve ..	£10,225	£10,697
Dividend ..	15 p.c.	15 p.c.
Balance carried to reserve	£4,493	£4,905

At the meeting of the Tharsis Sulphur and Copper Company the report of the directors showed that 33,480 tons of ore had been extracted during the year ending December 31st, a decrease of 17,261 tons over the previous year. The net profits of the company amounted to £253,066, and it was proposed to pay a dividend of 20%.

The Lagunas Nitrate Company's report for the past year shows a total profit of £40,143. For the past twelve months a dividend of 2% is recommended, and £20,000 is to be transferred to the reserve fund. Additional plant is now in the course of erection, and will be completed during the current year.

At the ordinary general meeting of the Cordoba Copper Company, Ltd., held on April 9th, the chairman said that the total receipts for the past year amounted to £166,000 as against £133,000 for the previous fifteen months, so that there had been a considerable increase in output. It was proposed to pay a dividend of 20%.

At the recent meeting in Glasgow of the Selanger Rubber Company, a dividend of 250% was announced, making 1,355% for the last fourteen years.

The report for 1912 of the Eastman Kodak Company of New Jersey again shows a further remarkable advance on the previous records of the company. After making provision for depreciation on buildings, plant and machinery the net profits amount to £2,886,401; an increase of £484,491 over the previous twelve months. Dividends of 6% upon the preferred capital, and 40% upon the common have been distributed, leaving £1,200,236 to be added to the undivided surplus fund, increasing it thereby to £3,609,780. The earning power of the company shows a steady increase, as will be seen from the following table of annual earnings:—

Year.	£	Year.	£
1895 ..	49,656	1904 ..	688,484
1896 ..	122,676	1905 ..	827,610
1897 ..	185,232	1906 ..	1,116,639
1898 ..	243,232	1907 ..	1,446,479
1899 ..	335,919	1908 ..	1,540,725
1900 ..	465,816	1909 ..	1,619,087
1901 ..	517,347	1910 ..	1,850,552
1902 ..	564,455	1911 ..	2,401,910
1903 ..	606,740	1912 ..	2,886,401

The American copper-producing concern of Phelps, Dodge and Company, increased its profits by \$3,128,000 for the past year, and paid a dividend of 15%.

Representatives of British and French syndicates owning oil-mining industries in California have been informed that the Bill forbidding the holding of land by foreigners, which is now before the State Legislature, will apply equally to Europeans and Orientals.

CORRESPONDENCE.

Bordeaux Mixture.

SIR,—Under the title of "The Chemistry and Fungicidal Action of Bordeaux Mixture" an article by Mr. C. T. Gimingham, of the Bristol University, appeared in the November issue of THE CHEMICAL WORLD. I read this ably written paper with much interest, as the question of insect and fungicidal agents is a very burning one on this side of the globe, where pests of all kinds are much in evidence and have to be dealt with. Mr. Gimingham discourses on the action of CO₂ in rendering the copper of Bordeaux Mixture soluble and hence effective as a fungicide, but he questions the sufficiency of this agent under ordinary atmospheric conditions to induce the result. Now without pretending to contravene this view, which may be the correct one, I would only raise a doubt whether Mr. Gimingham has attached sufficient importance to the consideration of the large quantity of CO₂ evolved by plants in the process of respiration, which goes on as freely in the night as in the daytime, and is, of course, to be taken as a thing quite apart from the carbon assimilation process carried on by leaf chlorophyll. Respiration, moreover, goes on all over the plant wherever living cells are found, and is alike carried on by the fungus, as well as by the higher forms of vegetation. Kerner, in his "Natural History of Plants," says: "It has, however, been ascertained that seedlings of poppy (which, when subscantly dried, weighed 0.45 gramme) exhaled 55 cubic centimetres of carbon dioxide, and seedlings of

mustard (which, when dried, weighed 0.55 gramme) 32 cubic centimetres in the same time." This very considerable amount of CO₂ would during the night-time tend to become to a large extent dissolved in the transpiration vapour emanating from the leaf pores and condensing on the surface of the leaf, in which situation it might be supposed to act readily upon the copper of the Bordeaux Mixture. I have at the present moment some small pot cultures of grass going forward to test a certain phosphatic manure. To prevent too rapid drying, the pots are usually kept under a bell jar, and when so placed a liquid bead collects at the tip of each blade of grass. The bead or globule when tested is distinctly acid in reaction, both in the case of the manured and unmanured pots. I have not as yet been able to collect sufficient of the liquid to determine whether the acidity is wholly due to the presence of dissolved CO₂ or not, but an acid reaction of such strength is indicated that the copper of Bordeaux Mixture would be more than likely to be affected by it. Further research in this direction is desirable, and should be carried out by those who have the leisure and the necessary equipment of phyto-chemical apparatus.

HENRY J. COLBOURN,

Chemist to the Department of Agriculture, Hobart,
March 10th, 1913.

COMMERCIAL AND GENERAL NOTES.

American Sulphur Factory in Holland.

The New York Union Sulphur Company, of New York, which owns very large sulphur mines in Louisiana, has entered into negotiations with the Town Council of Rotterdam for the lease of an extensive area on which to build a sulphur factory. The American Company is most anxious to erect its buildings close to the docks, as it is intended to do a large shipping trade in sulphur and sulphur products.

New Substitute for Horn.

As everyone interested in the trade knows, there is quite a number of useful horn substitutes on the market. The composition of these is of a very diverse nature; we only mention those which have casein for a basis, such as galalith, or the different products obtained by condensing phenol and formaldehyde, etc. The object of a new German patent is a process which combines leather and celluloid. The utilisation of celluloid for the purpose of waterproof leather alone is no novelty, having been in existence for many years. According to the new process, the hide is freed from hair and fleshy matter by means of amylacetate and acetone, which has a hardening effect. Subsequently it is coated with a solution obtained by dissolving celluloid in amylacetate and acetone. When this has evaporated, the hide is placed in a bath consisting of shellac dissolved in alcohol. Hide prepared in this manner is not only similar to horn, but also possesses its elasticity and strength. It is very suitable for making strong but light articles, such as trunks, boats, etc., and being a good insulating material it may also be used for electric purposes.

Ultra-Violet Rays for Sterilising Drinking Water.

Considerable attention is being given in France to practical applications of the sterilising action of the ultra-violet rays, and a sphere in which it is thought they may render excellent service is the purification of the drinking water supplied to travellers in railway stations. According to a paragraph on this subject in the engineering supplement of the *Times*, it is a difficult matter to guarantee that the water used for this purpose is free from infectious germs. The French railway companies generally use some type of porcelain filter for purifying the water, but the output of these is very small, and the cost of upkeep is great owing to the constant attention they require. To obviate these drawbacks the Nord Railway Company have decided to adopt sterilisation by ultra-violet rays, and installations are being prepared for their Paris terminus and other large stations which possess the requisite supply of electricity.

The rays are to be produced by means of quartz mercury vapour lamps of the Westinghouse Cooper-Hewitt type. The apparatus consists of a quartz lamp tube, from which the rays are emitted, surrounded by a cylinder containing a translucent quartz pane, through which they pass directly into the water. The lamp and outer jacket are fixed centrally in the axis of a small cylindrical water reservoir. By means of a special arrangement of vanes, the water is caused to pass four times in front of the quartz pane before reaching the outlet pipe. An automatic valve stops the flow of the water when the lamp is not working, and the water then runs to waste. As soon as the lamp lights up the water again flows through the reservoir. This arrangement ensures that all the water supplied by the apparatus has been sterilised.

The apparatus, which is made by the Société Française pour les Applications des Rayons Ultra-violet, takes up little space, and can supply 600 litres of sterilised water per hour with an expenditure of 385 watt-hours of electric energy. Its actual working cost is, therefore, insignificant. The cost of the installation, not including the water pipes or electric wiring, is about 1,000 francs. Bacteriological analyses show that the water, when it leaves the apparatus, is effectively sterilised, and it is not in any way changed to the taste.

An International Hygienic Exhibition in Lima (Peru).

During the last two months of the current year a medical convention will be held in Lima (Peru). At the same time an International Hygienic Exhibition will be arranged, which offers manufacturers of chemicals, sanitary appliances, and hygienic apparatus an opportunity of placing their goods before prospective buyers. The exhibition will contain two separate divisions; one of these will be of an industrial nature and embrace medical, chemical and hygienic instruments, etc., while the other division is intended to be of a scientific nature. There will be no charge for space, but the costs of transportation and any expenses for special installation, etc., have to be borne by the exhibitors. The Peruvian Government have consented to admit the goods free of duty, provided a deposit be made by the exhibitor amounting to the usual import duty. Intending exhibitors must send in their goods before September 1st. All details may be obtained by application to the "Presidente de la Comisión Ejecutiva de la Exposición de Higiene, Academia de Medicina de Lima, Plaza de la Exposición, Lima, Peru."

New Fuel for Motor Vehicles from South Africa.

A new locally invented fuel for use in internal combustion engines has lately attracted considerable attention in Johannesburg. The inventors of this gasoline substitute have placed it on the market under the name of "Parol." It is made from paraffin, its conversion being accomplished by a chemical process and without the use of heat. Aside from the chemicals used, the only accessories required for the preparation of the fluid in large quantities are tanks, pumps and mixers. It is claimed that by means of the chemical process employed the property which creates carbon in the cylinders and forms soot around the sparking plug is removed, and the strong odour of paraffin is likewise eliminated. The paraffin which has been used in all of the tests up to the present time is of 150° fire test. It is the intention of the inventors of Parol to come to England shortly for the purpose of competing in various tests organised by the Royal Automobile Club for fuels other than petrol.

Occupational Diseases in Chemical Trades.

A Committee on Occupational Diseases in the Chemical Trades was appointed by the New York Section of the American Chemical Society in February, 1912. The objects of the Committee may be specifically stated as follows:—

1. To hold itself ready to advise the legislatures of the States of New York and New Jersey in reference to matters pertaining to occupational diseases in the chemical trades.
2. To study various Bills presented in the legislatures in an effort to avoid unwise legislation.
3. To inaugurate and superintend such investigations as might be decided upon which aim at the improvement of conditions of labour in the chemical trades.

The reports on the work undertaken up to the present will soon be available. Among the suggestions contained therein is one which involves the appointment of a chemical engineer as one of the four members of the Division of Industrial Hygiene of the proposed reorganised Department of Labour.

Profits from the Manufacture of Artificial Silk in Belgium.

Whereas the German firms manufacturing artificial silk by the gun-cotton process have the greatest difficulty in working without considerable losses, the Belgian makers are in a more fortunate position. The explanation seems to be the fact that they have a cheaper supply of industrial alcohol and ether required for the old gun-cotton process. One of the most successful undertakings in this branch of the industry, the Société de la Soie Artificielle de Tubize, has recently published the balance-sheet and a detailed report on the results obtained during last year. According to this report important improvements have been made in the manufacturing process, an extension of the works has been accomplished, and the daily production increased by about 1,500 kilos. The net profits of the concern amounted to over 3 million francs, and the whole production of the current year has been sold at satisfactory prices.

In view of recent developments in the viscose process, both in this country and abroad, the success of the nitro-cellulose process suggests a high state of organisation at the Tubize factory, a very thorough recovery of solvents, and perfect control over the denitration process.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.

25496/11. R. DE FAZI, Rome. **Oil Distillation.** 15 November, 1911.

Crude mineral oils are treated with sulphuric acid and distilled in the presence of quicklime slaked with water, the vapours then being passed through a mixture of lime and carbon. (2 claims—1 Fig.)

3512/12. L. BLOCK, Mamaroneck. **Ammonia.** 12 February, 1912.

Ammonia gas is condensed by forcing the gas upward through the successive horizontal passages of a trombone coil, over the exterior surface of which a cooling medium flows, the gas being introduced into the coil at a velocity sufficient to overcome by momentum the gravity of the liquefied ammonia as it is condensed. (4 claims—8 Figs.)

3805/12. H. SPENCE, W. B. LLEWELLYN, and PETER SPENCE & SONS, LIMITED, Manchester. **Alumina.** 15 February, 1912.

The purification of solutions of sulphate of ammonia from iron oxide is effected by treating the solution with potash in the presence of unground calcined coal measure or like shales. (6 claims.)

5855/12. G. TISCHENKO, St. Petersburg. **Iron.** 8 March, 1912.

In apparatus for the refining of scrap iron by electrolysis, the anode and cathode chambers are both formed as vertical concentric cylinders arranged so that either can be separately raised out of the electrolytic bath without disturbing the other. (5 claims—4 Figs.)

6176/12. CHEMISCHE FABRIK GRÜNAU, LANDSHOFF AND MEYER, AKTIENGESSELLSCHAFT, and W. KIRCHNER, Grünau. **Barium Oxide.** 12 March, 1912.

In the manufacture of barium oxide by heating barium carbonate mixed with carbon, the raw material is heated to about 1,000° C., or higher, in a receptacle which remains perfectly impermeable to the carbonic acid of the heating gases. (2 claims.)

7740/12. P. O. ROWLANDS, Liverpool. **Ammonia.** 30 March, 1912.

The production and/or recovery of ammonia from nitrogen and/or ammonia-bearing compounds is effected by immersing the compound in an alkaline electrolyte and subjecting the same to electrolytic action. (1 claim.)

12051/12. O. DIEFEENBACH and W. MOLDENHAUER, Darmstadt. **Hydrogen.** 24 May, 1911.

In the production of hydrogen by alternate treatment of metallic iron with steam and reduction of the resulting iron oxides by means of reducing gases, alloys of iron with manganese, chromium, tungsten or titanium are used as initial material. (2 claims.)

12168/12. W. S. ROCKEY and H. ELDRIDGE, New York. **Copper.** 22 May, 1912.

Copper is refined by first fusing it by heat, and then directing the fused copper through a bath of fused anhydrous boron trioxide and maintaining the heat of the copper until all occluded gases have been expelled and the oxides present dissolved by the boron trioxide. (3 claims.)

12845/12. BADISCHE ANILIN AND SODA FABRIK, Ludwigs-hafen-on-Rhine. **Ammonia.** 31 May, 1912.

According to this invention, sulphate of ammonia is manufactured directly from sulphites of ammonia by heating ammonium bisulphite with a catalytic agent. (7 claims.)

16619/12. VEREINIGTE CHININFABRIKEN ZIMNIER & Co., G.m.b.H., Frankfort-on-Maine. **Hydrocupreine.** 16 July, 1912.

Alkyl-derivatives and substituted derivatives of hydrocupreine are manufactured and produced by treating hydrocupreine with a suitable alkylising agent. (3 claims.)

17027/12. FARBENFABRIKEN VORMALS FRIEDRICH BAYER & Co., Elberfeld. **Dyestuffs.** 22 July, 1912.

New yellow wool dyestuffs of the anthracene series are manufactured by a process which consists in combining the diazo compounds prepared from amino-anthraiso-thiazote sulphonic acids with aceto acetic acid or its amide or arylamides. (2 claims.)

17397/12. W. M. CALLENDER, Guernsey. **Isoprene.** 24 February, 1912.

Isoprene is manufactured by passing the mixed vapours of turpentine and an oil or spirit having about the same boiling point as turpentine through a heated tube and separating from the product that portion which distils up to 70° C. (2 claims.)

19604/12. A. H. COWLES, New Jersey. **Hydrochloric Acid.** 27 August, 1912.

A charge mixture for producing hydrochloric acid and alkali-silico-aluminate is composed of aluminosilicious compounds, said compounds being preferably non-ferruginous, in combination with an alkali chloride and carbon. (5 claims.)

22717/12. J. KERSTEN, Dellbruck. **Alkaline Hydroxides.** 5 October, 1912.

A process of producing alkaline hydroxides directly from alkaline chlorides by converting the latter by means of oxides of the heavy metals is characterised by the employment of hydroxide of lead for this purpose. (2 claims.)

24779/12. THE FIRM DR. C. RUDER & Co., Hamburg. **Camphor.** 6 December, 1911.

In the manufacture of camphor from borneol and isoborneol by oxidation with chromic acid mixture, a non-oxidisable solvent is added gradually in such manner that the progress of the reaction is regulated so as to prevent the heat of reaction produced by the oxidation leading to local overheating. (3 claims.)

402/13. G. S. A. APPELQVIST and E. O. E. TYDEN, Stockholm. **Ore Concentration.** 6 January, 1913.

In the method of concentrating ores in a liquid by means of oil, tar or fat gasified by heating, the ore and the gasified oil, etc., are introduced into the liquid in such manner that they mix with one another just when entering the liquid. (6 claims—2 Figs.)

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"Science moves, but slowly, slowly creeping on from point to point."—TENNYSON.

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Surely the officials connected with the War Office must realise that they are working one of their departments under conditions which are inferior to those existing in a first-class manufacturing firm of to-day. And how can one compare the relative interests and responsibilities of such an organisation as the War Office under modern

conditions with, say, that of a private firm, manufacturing artificial silk, or dealing with the manufacture of bicycles?

Another point put before the Commissioners by these witnesses is an important one. In the general interest of the country it is absolutely essential that those following the profession of chemistry should be treated in such a way that they can occupy a social position which is equivalent to that occupied by members of kindred professions or the highest class of Civil Servants. With such conditions the Government are making this more than difficult, and those with the brighter brains may, if these facts become generally known, enter other professions than that of chemistry.

It is, however, necessary to point out that such conditions do not apply to Government service generally, and that the present unsatisfactory condition arose at the time the research department was established. This was brought out by Dr. Dobbie in his evidence, dealing with the Government Laboratory, where a most satisfactory state of affairs clearly exists. He claimed that they were not short of good men, as judged by academic qualification, for their posts, and this appears to be so.

It was also pointed out in evidence that the Government services are in a difficult position in certain directions with their head chemists, owing to the fact that they may be offered much higher salaries and positions in private firms—and take them. It may be that the Government, in these democratic days, dare not offer such fees to chemists as a private firm can do, but when one remembers those absorbed by the legal profession this cannot stand in the way of further reforms, if they are found to be necessary.

In the present day it is not so much a question of attracting chemical workmen, as original investigators, into the Government service. Men who continually improve methods and devise new processes. For this it is necessary to offer such inducements as will enable them to realise that they have prospects before them which are equal to those obtained elsewhere. There can be little doubt that if the Royal Commission accepts the above evidence in its report, the War Office will deal with the matter in a proper spirit and on lines of modern progress.

The Chemist and the General Press.

It is perhaps unfortunate that this evidence should have apparently given rise to a general discussion in a section of the Press.

Vague letters to the Press from chemists, who faced the music under the names of well-known reagents, will hardly tend to increase the status of the chemist in the estimation of the public.

Alleged conditions such as those which have recently come to light in connection with the War Office and the employment of chemists, must be dealt with by the profession itself, through the Royal Commission. They are not improved, or modified, by any discussion in the general Press.

If the impression once gets abroad, that chemists as a class are prone to call over their domestic troubles in the market-place, the effect produced will be an unsatisfactory one. Action of this order is generally associated with a lost cause.

Such general statements as the one that manufacturers persistently ignore the aid of properly trained chemists is contrary to present-day practice. It is for members of our profession to see that progress in this respect is not retarded by ill-considered effort, and probably a little more thought in the future will indicate that these subjects are best considered from a domestic point of view.

The public are greatly interested in results, but they are easily "bored" when asked to consider details involving the status, and remuneration, of those who produce them. The chemist must develop the business instinct, and work out his own salvation.

Rag Flock Act (1911).

An interesting series of papers on the working of the Rag Flock Act of 1911 was recently read before the Yorkshire Section of the Society of Chemical Industry. Objection seems to be taken in certain directions to the present chlorine test, as mentioned in the Local Government Board Report of 1910. This turns upon the statement that the chlorine factor may not alone indicate organic impurities, but also certain chemical substances containing chlorine, which may be present in certain flocks. It was also pointed out that objectionable substances (fæces) may be present, which would not be recognised by the chlorine test. Also that some samples of wool flock materials, which have not been worn since leaving the manufacturer's hands, may contain chlorides largely in excess of the figures set out by the Local Government Board as indicating an impure flock.

Professor Green, in the discussion which followed the papers, considered that "the chlorine test alone was obviously quite fallacious," and could not alone be regarded as a safe guide. It was even pointed out that the chlorides in water used for washing the flock in the mill might on the dry flock show, in a not impossible case, 30 parts of chlorine per 100,000 parts of the material. An interesting point brought out by Dr. Ingle was that a flock extracted by washing with water returned 71 parts of chlorine per 100,000, but that it actually contained total chlorine to the amount of 270 parts per 100,000, or nearly four times that yielded to water. This is a point which certainly requires further consideration.

It is fairly obvious that the chlorine test as suggested by the Local Government Board experts is largely based on conclusions which may not correspond with certain possible conditions as they exist in practice, and that if, as was suggested, the help of technical men had been called in, in framing such tests, results might have been obtained which would more certainly indicate the presence of objectionable impurities. As a number of firms have been prosecuted under the Act, this is a matter of importance.

RECENT ADVANCES IN THE CHEMISTRY OF "LIPO-CHROMES," OR FAT SOLUBLE COLOURING MATTERS OF NATURAL ORIGIN.

By G. W. MONIER-WILLIAMS, M.A. (OXON.), PH.D., F.I.C.

THE term "lipochrome," or "lutein," has been applied to a group of yellow and red colouring matters of animal and vegetable origin, which are extraordinarily widely distributed in nature. These substances are characterised by their solubility in fats and oils and in most of the usual organic solvents, while they are insoluble in water and dilute acids and alkalies. They are gradually oxidised and bleached on exposure to air, give intense blue, greenish-blue or violet colorations with concentrated sulphuric or nitric acids, and show in most cases characteristic absorption spectra in the blue and violet.

In 1869 Thudichum¹ proposed the name of "luteins" for these colouring matters, and included under this name the pigments of egg yolk, blood serum, milk fat, and certain roots, berries and plant juices. Some years later the researches of Krukenberg, Kühne, Zopf, Kutscher and others showed that pigments possessing the characteristics of Thudichum's "luteins" occur in representatives of almost every zoological class from protozoa to mammalia, and the term "lipochrome," *i.e.*, fat-soluble pigments, proposed by Kühne, is now generally accepted for this group of substances. Very few lipochromes have as yet been isolated in the pure state, owing to the great difficulty of separating them from the accompanying lipid bodies, and it is probable that the actual number of individual colouring matters of this group is comparatively small, in spite of the many different names proposed for them by various investigators. Such names as crustaceorubin, cyanocrystallin, tetronerythrin, diaptomin, coleopterin, vitellolipochrome, lacertofulvin, zoonerythrin, etc., have been given to lipochrome pigments from various sources, although in the great majority of cases the substances have not been isolated in anything like a pure state.

Certain broad classifications of lipochromes have been attempted, based on differences in solubility and spectroscopic behaviour. Thus Kühne distinguished between "chlorophanes," soluble in chloroform and ether and showing two absorption bands in these solvents, and "rhodophanes," soluble in alcohol and showing one absorption band. A far better classification is that of Borodin, Monteverde and others, who distinguish two groups, the one easily soluble in light petroleum but with difficulty in alcohol, and the other soluble in alcohol but not in light petroleum. This division into groups, although originally applied only to vegetable lipochromes, would appear, according to Willstätter, to be of general application to those of animal origin as well.

Of the lipochromes soluble in light petroleum the best known is carotene, the orange pigment which is so conspicuous in carrots. Carotene was isolated in the pure state by Arnaud,² and has been shown to be a highly unsaturated hydrocarbon of formula $C_{40}H_{56}$. It can easily be obtained by thoroughly boiling minced carrots with water, drying the residue, and extracting with carbon disulphide. A deep red extract is obtained, from which the carotene may be precipitated in an almost pure state by the addition of light petroleum. About 2 gms. can be obtained in this way from 1 cwt. of carrots, and, by recrystallising from a mixture of carbon disulphide and light petroleum, the pure substance is obtained in the form of deep red leaflets melting at 167° to 168° C. As its formula implies, it is a highly unsaturated body, absorbing oxygen from the air to the extent of over 30% of its weight, the deep red colour being thereby discharged. It absorbs nitrogen peroxide with considerable evolution of heat, gives a crystalline addition product with two atoms of iodine, and, on complete bromination, yields the substance $C_{40}H_{36}Br_{22}$. It is characterised by a great capacity for absorbing blue and violet light, a thickness of 10 mm. of a solution in light petroleum containing only 0.005 mgms. per cubic centimetre, showing well-defined bands at approximate wave lengths 476, 447, and 420 μ .

Willstätter has shown that carotene, although occurring principally in carrots, is present, together with chlorophyll, in the chloroplasts of a great many plants. He isolated it in considerable quantity from nettle leaves, and considers it to be the most important and widely distributed member of this group of lipochromes.

The second group, comprising lipochromes soluble in alcohol, consists of substances very similar to carotene in their chemical behaviour but containing oxygen. According to Willstätter,³ the colouring matter xanthophyll, isolated by him from nettle leaves and found to possess the formula $C_{40}H_{56}O_2$, is the chief representative of this group. Xanthophyll was obtained as a bye-product in the preparation of chlorophyll, and differs slightly from carotene in colour, crystalline form, solubility in various solvents, etc. It crystallises in orange-red platelets with steel-blue reflex, melts at 173° C., gives a crystalline compound with iodine ($C_{40}H_{56}O_2I_2$), and, on complete bromination, the compound $C_{40}H_{40}Br_{22}$. It does not give the reactions either of an alcohol or of a carbonyl compound, but shows the typical lipochrome coloration (deep blue) with concentrated sulphuric acid. The positions of the absorption bands in alcoholic solution are somewhat

¹ *Proc. Roy. Soc.*, 17, 253, 1869.

² *Comptes Rend.*, 102, 1119, 1886.

³ *Annalen*, 355, 1, 1907.

different to those of carotene. All attempts to produce xanthophyll by partial oxidation of carotene have failed, and very little is known of the constitution of these bodies.

A second member of the carotene group was isolated by Willstätter and Escher⁴ from tomato pulp and has been called by them "lycopene." It is a hydrocarbon with the same molecular formula as carotene and almost the same melting point (168° to 169° C.), but differs from carotene in the position of the absorption bands.

The lipochrome of egg yolk has been investigated by several observers. Following on Thudichum's classification of certain natural pigments, including that of egg yolk, as "luteins," Kühne gave to it the name of "ontochrin," or "lecitochrin," and, although unsuccessful in obtaining it in a crystalline state, compared its absorption spectrum with that of the pigment occurring in the *corpus luteum* of mammalian ovaries. He showed that these two pigments are not the same, that of the *corpus luteum* being very similar to carotene. Some years later Schunck found that the absorption spectra of the colouring matters from egg yolk and blood serum are identical.

The recent isolation by Willstätter and Escher⁵ of this lipochrome in quantity sufficient for analysis marks a notable advance in this field of research. By working on the yolks of 6,000 eggs, weighing in all about 110 kilos., they succeeded in isolating 4 gms. of the crude colouring matter, from which about 2½ gms. of the pure substance were obtained. It crystallised from carbon disulphide in orange-red prisms, melting at 195° to 196° C., and gave on analysis figures corresponding to the formula $C_{40}H_{56}O_2$, being thus isomeric with xanthophyll from green leaves. The two substances are not identical, as xanthophyll melts at 173° to 174° C.; but in all other respects their properties are exactly the same, and the positions of the bands in the absorption spectra of both substances are identical.

The latest contribution to this subject is a paper by Escher,⁶ dealing with the yellow pigment of the *corpus luteum*. This colouring matter seems to have been one of the first lipochromes to be obtained in a state of approximate purity, a minute quantity having been isolated in the form of crystals by Piccolo and Lieben as long ago as 1865, and, independently, by Städeler and Holm two years later. The pigment was recognised by Thudichum as belonging to the group of "luteins," and Kühne, by a comparison of its absorption spectrum with that of carotene, indicated the close relationship existing between these two substances.

By extracting the pigment from 10,000 ovaries, Escher has now succeeded in preparing about ½ gm. of the pure substance, and has shown that it is indistinguishable from the carotene obtained from carrots or from green leaves.

Up to the present, therefore, the following lipochromes have been prepared in the pure state, and

their molecular formulæ and properties determined:—

Soluble in Light Petroleum.

Soluble in Alcohol.

Formula $C_{40}H_{56}$.

Formula $C_{40}H_{56}O_2$.

Carotene from carrots.

Xanthophyll from green leaves.

" " green leaves.

"Lutein" from egg yolk.

" " mammalian ovaries.

Lycopene from tomatoes.

It is highly probable that the yellow colouring matter of milk fat belongs to the carotene group, as the absorption spectrum of a solution of this fat in light petroleum is practically identical with that of carotene in the same solvent, and the same is probably true of the yellow pigments occurring in many other animal fats.

Other lipochromes of which crystals have been obtained are those of the protozoon *Euglena viridis*, obtained in the form of small garnet-red crystals, and of the hypodermis of lobsters (crustaceorubin), but the nature of both is uncertain. The shells of lobsters contain a blue colouring matter of complex nature, which can be obtained in solution by dissolving the calcareous portion of the shell in 0.1% hydrochloric acid, precipitating with ammonium sulphate and extracting the precipitate with alcohol. On warming the solution to about 50° C. a red colouring matter is formed, which shows the characteristic lipochrome reactions, and is probably nearly related to the crystalline crustaceorubin of the hypodermis.

An interesting group of lipochromes has been described as existing in the retina of the eye, being most conspicuous in the eyes of birds. In the retina are minute oil droplets containing differently coloured pigments in solution. It has not yet been found possible to isolate any of these colouring matters in the crystalline form, although Kühne claimed that a partial separation into three different substances, termed by him "chlorophane," "xanthophane" and "rhodophane," may be effected by extracting the saponified oil with different organic solvents. The colour of the extracts and the position of the absorption bands are different in all three. It is impossible, however, at present to regard these as definite chemical individuals, as they are accompanied by large amounts of other unsaponifiable matter, which may exert a considerable influence upon both the solubility relations and the absorption spectra. The absorption spectra in particular of all lipochromes are much affected by variations in the solvents employed. Owing to the minute quantities of colouring matter present and the difficulty of obtaining sufficient raw material, the actual isolation of the lipochromes of the retina is probably far distant, but the subject would appear to be of unusual interest, having regard to their great capacity for selective absorption of light.

On studying the literature dealing with animal lipochromes one is struck by the frequency with which they have been described as occurring in the

⁴ Zeitsch. für Physiol. Chem., 64, 47, 1909.

⁵ Zeitsch. für Physiol. Chem., 76, 214, 1912.

⁶ Zeitsch. für Physiol. Chem., 83, 198, 1913.

female reproductive organs and eggs. This is especially noticeable in the case of birds' eggs and in the *corpus luteum*, and it has, moreover, been stated that in certain crustacea it is in the blood serum of the female only that these pigments occur. Among plants again lipochromes are frequently present in fruits and seeds from which chlorophyll is absent. The suggestion has been made that they may act as oxygen carriers in the formation of

chlorophyll in plants and hæmoglobin in animals, and that their presence in the embryo is preparatory to the formation of these colouring matters. We have as yet, however, no data which can justify us in ascribing to them any such particular physiological function, and it must be left to the future to decide whether their occurrence is in most cases purely adventitious or whether and in what way they are essential to the organs in which they occur.

THE ELUSIVE COLLOID.

By C. F. CROSS.

THE recent symposium organised by the Faraday Society on the subject of "colloids and their viscosity" necessarily raised the larger issue, which our German cousins would term "Das Wesen des Kolloidzustandes." As a matter of clear definition it must be mentioned that the "viscosity of colloids" is a term which is liable to be confused with "viscosity of colloidal systems." Such quantitative measures of viscosity as were demonstrated and discussed were those of systems of actual colloid and dispersion medium: the complications of such systems being evident, and making it impossible to apply to the treatment of the phenomena of disperse viscosity any mental picture such as chemists have come to regard as the basis of exact investigations in their own domain.

It is perhaps a matter of metaphysics or psychology to compare the methods of investigation of the chemist and physicist *qua* method. The contrast is obviously most marked in attacking problems of the borderland region between the two sections of science, and it might be a fruitful enquiry in relation to this particular subject of colloids, in which it would certainly appear from the records that much time has been spent upon the mere formalities of terminology: *vide* the controversy as to whether the phenomena of dyeing are mainly "chemical" or "physical." But it would require a master of mental science, equipped with experience of methods of laboratory investigation, to analyse the position and draw the moral in such form as would commend itself with authority. Many of us, perhaps most of us, as workers and investigators use our mental equipment all unconsciously: our methods are justified (or not) on the standard of results. They are so far empirical: the basis of judgment is experience, the alternative abstract consideration of method is, we think, discredited according to the fashion or convention of our schools, which leaves the grammar of natural science to the "curious and eccentric" individuals, vaguely termed "philosophers."

Leaving the region of generalities with this confession of a personal general impression, we return to the particular point, which we may formulate as a question—How best to attack the

central problem of the colloidal state? The chemist is primarily concerned with types of colloidal matter, and, indeed, with such prototypes as have conspicuous functions, in the "natural" worlds of organic and inorganic matter. An exhaustive study of these is, he considers, calculated in due time to supply material for generalisation, and to advance us towards a general grasp of the colloidal state. In this we think the chemist takes the more objective attitude. The physicist rather seizes upon a general and complex unrelated property, such as "viscosity," and uses a range of colloids as particularly illustrating and quantifying its phenomena.

The results of this method of study and investigation are well set forth in the various published contributions to the symposium together with the commentary of the discussions to which they gave rise, and which, we think, more definitely raise the question *a priori*, how best to investigate the general problem of the colloidal state, and whether the alternative perspective of the chemist does not promise the immediate best.

From the chemical investigations of typical colloids, there is an accumulation of quantitative results, tending to establish some important positions. Thus, synthetic reaction in a colloidal mass is continuous, up to the limits defined by the stoichiometrical relations of the ultimate constituent reacting groups. Whereas molecular reactions are ideal limiting cases, and much of our molecular chemistry implies that the same relations hold integrally for the reacting mass, the colloidal mass is, on the other hand, an aggregate of units constituting a reacting system, in which changes are continuous.

Further, the structural properties and relationships of certain colloids enable us to follow continuously the changes from the state of solution to that of solid, from which it appears that "viscosity," measured in the former state in which it is a mixed phenomenon of colloid and dispersion medium, is in effect a property of the colloidal matter itself, as an aggregate, which in turn may depend upon and express a special configuration of the ultimate component units.

Several definite problems in quantitative measurements are here involved, such as the

relation between viscosity of solutions, and mechanical properties of solids reverted therefrom. As a concrete case: starch and cellulose, though integrally made up of hexose units, are widely differentiated as forms of matter from their constituent unit groups considered as dextrose. The divergence in properties, including of course the conspicuously colloidal characteristics of these compounds, would be explained by the chemist, (1) by their constitution as polymerides of the hexose anhydrides, or (2) by anhydride formation and polymerisation in association with changes of configuration of the units: these latter changes being of a fundamental order, and especially determining the typical characteristics of these compounds. In such views the habitual mental pictures of the individual chemist must come into play. We say "habitual," since we cannot dissociate any problem in "organic" chemistry from the general fabric of the science in which diagrams of constitution and configuration have become essential to our mental processes of conception and analysis.

Thus, as a mental picture of a unit group of C_6 dimensions, it is reasonable to assume the three possible variations: (1) a grouping in the three dimensions of space of approximate equality; (2) a reduction in one or two dimensions to a minimum, giving, that is, the form of a disc in the one case, or a spindle-shaped mass in the other. We have grosser representatives of these forms in cells and fibres of organic tissue structures.

In applying analogous conceptions to ultimate forms of matter, we are indulging perhaps in a wild form of hypothesis—"wild" in the sense that it is not a hypothesis growing immediately out of, and generalising quantitative observations; and yet we appear to require some such hypothesis to account for the apparent suppression of discrete molecular units as reacting masses, and the merging of the molecule into a continuously reacting system.

It seems reasonable to assume that such particular configurations of unit groups may determine attractions of unit to unit, that is as between their constituent groups, greater than those which obtain *within* the units. Such attraction might be direct or of the indirect or inductive order.

As further illustration of phenomena presented for solution by such colloids as starch and cellulose, we have the striking fact that we can introduce negative groups into the system, *e.g.*, $O.NO_2$, $O.C_2H_5O$ with an increase of weight of 70 to 80% and with no sensible change of structural colloidal properties. A little reflection will show that these relations are by no means self evident; also their significance is much more profound than can be affirmed of the phenomena which specially attract the physicist.

It is well known from the history of chemical philosophy that it was by no means self evident that in the entrance of chlorine into a hydrocarbon radical (molecule) the constitutional type may be fully conserved, and that identity of function may

be true of such extremely divergent individuals as H and Cl.

It is in the present instance a question of conservation of typical properties of the colloidal aggregates through such extreme matter changes as accompany the ester reactions of starch and cellulose. We believe we may affirm that salt formation between inorganic polyhydroxides and these same negative radicals offers no parallel in regard to the relation of product to parent substance, as forms of matter. We think it will be granted as a fair working hypothesis that such phenomena presented by these colloidal prototypes postulate constitutional systems, in the chemical sense, outside any of the configurational relations as yet established: that such systems require to account for continuous reactions, and that the colloidal state implies a condition of matter not functionally "molecular," and its phenomena are not capable of interpretation in terms of molecular chemistry.

It is becoming evident on general grounds that the "organic chemistry," with which we are familiar, is a chemistry of limiting cases. It is evident that the investigation of the organic colloids adds emphasis to these views in presenting a case for a different order of conception, and treatment of certain forms of matter.

A symposium of chemists on this theme would be a valuable complement and worthy compliment to the Faraday Society's timely contribution to advancing science. Which of the Societies would organise this?

Stretching and Breaking of Sodium and Potassium.—

Mr. Bevan B. Baker recently described before the Physical Society how wires made of metallic sodium and potassium collapse when stretched, not to a point, as is the case with most plastic substances, but from two opposite sides only, into a chisel end. The wires upon which experiments were conducted were made in two ways: firstly, by pressing the metal through a small hole into a bath of paraffin oil to hinder oxidation; and, secondly, by running the metal, molten under oil, into a glass tube, and allowing it to solidify. Wires made by both the above methods showed the same behaviour on stretching. Wires made by the second process also showed, on extension, two sets of equidistant rings on their surface; each inclined at an angle of 45 degs. to the axis, the rings of opposite sets touching along the line of greatest thinning and bisecting one another along the line at which no thinning takes place. Dr. Andrade has also noticed the same effects of breaking and forming rings with wires made of solid mercury.

Hydrazine Nitrate.—Prof. W. R. Hodgkinson recently stated before the London Section of the Society of Chemical Industry that in connection with experiments on the removal of metallic fouling from guns a comparison had been made of the properties of ammonium and hydrazine nitrates. Hydrazine nitrate is a little less deliquescent than the ammonium salt, and although more soluble in cold water it is insoluble in alcohol. The dry salt melts at 70°, and may be kept at 100° for long periods without serious decomposition. At about 150° it inflames and burns quietly. It explodes with considerable violence when heated in a closed vessel.

ELECTRICAL AND THERMAL DISINTEGRATION OF METALS.

By G. W. C. KAYE, B.A., D.Sc., NATIONAL PHYSICAL LABORATORY.

(Continued from page 153.)

THERMAL DISINTEGRATION.

THE transport of matter from metals at temperatures well below their melting points is a familiar phenomenon to most people. A homely example is provided by the blackening which is a common enough feature of carbon filament lamps, and is occasionally displayed by tungsten filament lamps, especially when overrun. Sputtered images of a definite outline depending on the shape of the filaments can occasionally be traced on the globes of carbon lamps.

It has also long been known to high temperature workers that a thermo-couple of platinum and platinum-iridium alloy is liable to contamination by volatilised iridium if the couple is exposed for any considerable period to temperatures above about $1,000^{\circ}\text{C}$. (i.e., some 700° or 800° below the melting point of either wire).

This unfortunate property of iridium was experienced by the Reichsanstalt and the Carnegie Geophysical Laboratory at Washington when subjecting to high temperatures gas thermometer bulbs constructed of iridium or platinum-iridium; ultimately the use of iridium and its alloys had to be abandoned for such work.

Furthermore, workers with platinum-wound furnaces have remarked that on the porcelain tube of a furnace subjected to continued use at high temperatures crystals of platinum can often be detected along the edges of the platinum strip. Examples of these crystals are shown in Fig. 8. Sir William Crookes has obtained very beautiful hexagonal crystals in such circumstances.

The bulk of the work on thermal disintegration has been concerned with platinum and the platinum metals; it is only recently that the behaviour of other metals has been studied. The volatilisation of the platinum metals was first examined gravimetrically by a group of workers—Berliner, Elster, and Geitel, and Stewart—in 1887 to 1889. Holborn, with Henning, and later with Austin (*Phil. Mag.*, 1904), took up the matter in 1903 at the Reichsanstalt. Sir William Crookes (*Proc. Roy. Soc.*, 1912) has recently shown that the property is common in varying and unexpectedly large degree to the whole of the platinum group of metals.

The amount of disintegration exhibited by a metal when heated depends on:—

- (1) The nature of the metal.
- (2) The temperature of the metal.
- (3) The nature of the surrounding gas.
- (4) The pressure of the gas.

It will again be convenient to regard the subject from the point of view of each of these factors.

(1) *The Nature of the Metal.*—Whatever may be the extent to which chemical combination is interlocked with the phenomena of cathodic sputtering, there is little doubt that the gas plays in some cases of thermal disintegration a part not wholly physical. Probably the most reliable criterion of this is, does the effect diminish or increase as the pressure is lowered? To take the case of the metals platinum, rhodium and iridium; they all disintegrate less as the pressure is reduced, and in these instances we should suspect that extraneous causes were predominating. But with palladium, and indeed with most metals, a reduction of pressure is favourable

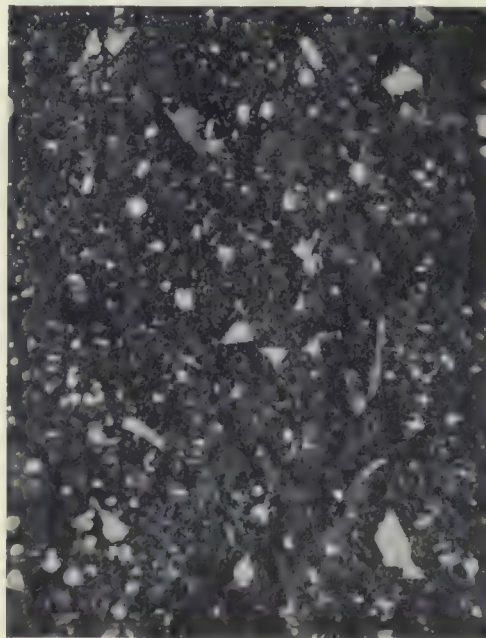


FIG. 8.—CRYSTALS OF VOLATILISED PLATINUM ($\times 20$ DIAM.).

to volatilisation, and here the effect is doubtless one of true sublimation.

Roberts (*Phil. Mag.*, 1913), working at the University of Liverpool, has recently brought forward evidence that the phenomena in the case of platinum (as well as with iridium and rhodium) are due to the formation of an oxide more volatile than the metal itself. Roberts heated a platinum wire in oxygen; he found that the weight of the black deposit which settled on the surrounding glass tube was equivalent to the weight of platinum disintegrated, together with a definite proportion of oxygen. The black deposit was insoluble in aqua regia, but decomposed when heated, yielding a bright platinum mirror which showed the customary

solubility in aqua regia. In order to correlate all the phenomena, it is necessary to assume that this oxide is endothermic and dissociates at a lower temperature than that at which it is formed. The fact that the rate of loss of weight of the platinum is roughly proportional to the oxygen pressure follows of course at once. It may be added that Wöhler in 1904 came to the conclusion that only two oxides of platinum really exist, viz., PtO and PtO_2 . Both are decomposed at about 400°C .

In Sir William Crookes' experiments, samples of the platinum metals were heated in still air at atmospheric pressure. His results are summarised in the adjoining table, and show a decreasing volatility in the order Ru, Ir, Pd, Pt, and Rh. As will be remarked, the effects are not of an order to be lightly disregarded by chemists using platinum crucibles at high temperatures; the loss of weight is comparatively large even at $1,300^\circ$. The disintegration is proportional to the time in the case of rhodium: with platinum it is somewhat greater for the first 20 hours than afterwards, when it becomes steady. This diminution of disintegration with time in the case of platinum has been noticed by many observers; it is more conspicuous the less pure the platinum, and is without doubt due to the removal of traces of iridium which are usually present.

Both palladium and iridium form oxides when heated in air; the abnormally large effect with ruthenium is due to the rapid formation of a volatile oxide.

PERCENTAGE LOSS OF WEIGHT IN AIR.

Heating.		Rh.	Pt.	Pd.	Ir.	Ru.
Temp.	Duration.					
	Hours	%	%	%	%	%
$1,300^\circ\text{C}$.	2	0.01	0.02	0.12	0.8	4.8
	5	—	0.05	0.26	2.0	15
	10	0.04	0.10	0.42	3.7	30 ¹
	20	0.08	0.19	0.61	6.6	—
	30	0.13	0.25	0.75	—	—
900°C .	10	0	0	0.09	0.6	—
	20	—	0	0.15	0.9	—
	30	—	—	0.18	—	—

Attention has recently been paid at the National Physical Laboratory to the volatilisation at low pressures of tantalum, tungsten, iron, zinc, silver and copper among other metals. Some of the results obtained are referred to elsewhere in this article.

(2) *The Temperature of the Metal*.—The disintegration of a metal increases rapidly with a rise in the temperature.

In the case of platinum, Crookes was unable to detect by means of a balance any signs of volatility in air at atmospheric pressure at 900°C ., even after 20 hours heating. Roberts (*Phil. Mag.*, 1913) has, however, shown, by means of a fog condensation

apparatus, that platinum exhibits infinitesimal disintegration even at 500°C .; so slight, however, is the effect, that it would take days of heating to produce any detectable loss of weight. The evaporation does not begin to be appreciable until the temperature reaches $1,100^\circ\text{C}$. or so; at higher temperatures it markedly increases.

Iridium responds conspicuously to the effect of temperature. Holborn and Henning (1903) record the hourly losses of a piece of iridium in air at atmospheric pressure as

12 milligrammes at $1,210^\circ\text{C}$.
72 " " $1,670^\circ\text{C}$.
277 " " $2,130^\circ\text{C}$.
[2,290 M.P.]

Sir William Crookes subjected an iridium crucible

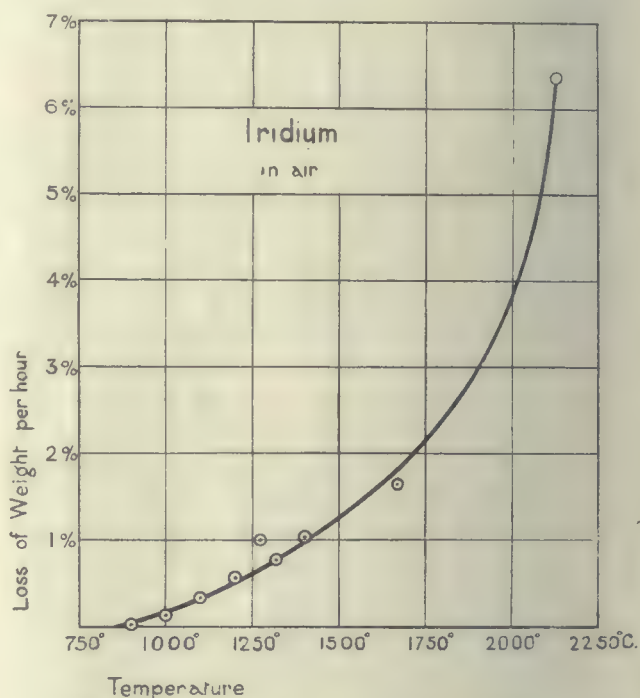


FIG. 9.

to a range of temperatures from 900°C . to $1,400^\circ\text{C}$. in still air at atmospheric pressure. Fig. 9, which is plotted from his results, connects the percentage rate of loss of weight per hour with the temperature. The two points above $1,400^\circ$ are those of Holborn and Henning, which have been reduced, as near as may be, to the same scale as that of Crookes.

(3) *The Nature of the Gas*.—Just as with cathodic sputtering, hydrogen and nitrogen are unfavourable to the thermal disintegration of most metals. Oxygen, as has been already noted, accentuates the effect in many cases; for instance, Holborn and Austin remark that platinum and rhodium disintegrate five times, and iridium eleven times as rapidly in oxygen as in air at atmospheric pressure.

In one experiment with oxygen, iridium lost 135 mgm. a minute at a temperature of $1,670^\circ\text{C}$., which is some 600° short of the melting point.

¹ Extrapolated.

All three metals disintegrate but slightly in nitrogen or hydrogen, and indeed almost all workers are agreed that the presence of oxygen is essential to give the effect in these cases.

The behaviour of argon and the other monatomic gases in cases of thermal evaporation does not appear to have been investigated; in view of the very marked cathodic disintegration which these gases bring about, the experiment ought to be tried.

Palladium is indifferent to the nature of the surrounding gas, and displays much the same effects quantitatively in air, oxygen, nitrogen or hydrogen. The deposit is black in oxygen, but is bright and metallic in other gases.

(4) *The Pressure of the Gas.*—The platinum metals, with the exception of palladium, all disintegrate less as the pressure is lowered. For instance, the rate of loss of weight of platinum and rhodium in air is about half as much at 25 mm. pressure as at 760. In the case of iridium, Crookes showed that at 1,300° C., the volatilisation was about 140 times as much in air at atmospheric pressure as in a good vacuum.

But, as has been remarked, the effects with these platinum metals are satisfactorily explained by the formation of volatile oxides, and they do not appear to provide true examples of volatilisation. With most other metals we should anticipate that the disintegration would be facilitated by a reduction of pressure. The following table gives data for a number of the less refractory metals for which information on the effect of pressure on their boiling points is available. The results are largely due to Greenwood (*Proc. Roy. Soc.*, 1910) and Krafft (*Ber. Deut. Chem. Ges.*, 1903 and 1905). A column of melting points is added for the sake of comparison.

Metal.	Boiling Point.			Melting Point at 1 Atmos.
	At Zero Press.	At 1 Atmos.	At 10 Atmos.	
	° C.	° C.	° C.	° C.
Cadmium ..	450	778	—	321
Zinc ..	545	918	1,180	418
Bismuth ..	1,000	1,420	1,900	269
Lead ..	1,140	1,525	2,020	327
Silver ..	1,400 ?	1,955	2,450 ²	960
Copper ..	1,600 ?	2,310	—	1,083
Tin ..	1,700 ?	2,270	—	232
Gold ..	1,800 ?	2,530 ?	—	1,062

The figures show how markedly the boiling point is affected by the pressure; having regard to the small gap between the melting and boiling points *in vacuo* with some metals, we should be justified in looking for appreciable volatilisation at temperatures about or below their melting points. Of this there is, of course, abundant evidence; the effect is in some instances outstanding. For example, copper begins to volatilise *in vacuo* at a little below 1,000°, silver

at about 680°, zinc at as low as 180° C. If copper and zinc are mounted alongside in a vacuum and exposed to a temperature of some 300° to 400°, the copper absorbs the zinc vapour and so becomes coated with an adherent film of brass.

Zinc is indeed abnormal in its ease of volatility even at higher pressures. Fig. 10 shows some beautiful crystals of zinc³ obtained by Dr. Rosenhain at the National Physical Laboratory. These were obtained by heating a piece of zinc for some weeks in a glass tube containing hydrogen at atmospheric pressure. The temperature employed was 300° C.



FIG. 10.—CRYSTALS OF VOLATILISED ZINC ($\times 20$ DIAM.).

Zinc, as will be seen, crystallises in the hexagonal system.

Several workers have shown that zinc, lead, copper, etc., volatilise appreciably in course of time, even at ordinary temperatures.

As has been noted, palladium shows an increased disintegration with reduction of pressure; for instance, Holborn and Austin found that by a reduction of pressure from 30 mm. to 0.2 mm., the loss of weight increased tenfold.

The volatility of platinum, iridium, tungsten, etc., when heated at low pressures is of great practical importance to the user of X-ray bulbs, who often employs anticathodes of these metals at a red heat.

(To be continued.)

³ For this photograph, as well as Figs. 8 and 17, I am indebted to the kindness and skill of Mr. S. L. Archbutt, of the National Physical Laboratory.

² At 6 atmos.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

DEPOSITS OF SILICA IN ICELAND.

By F. MOLLWO PERKIN, Ph.D., F.I.C.

IN the south west of Iceland, at Reykjanes, there exists, about one mile from the coast, a very large and interesting deposit of exceptionally pure silica. The formation of this part of Iceland consists of post-glacial lava, and the country is rough and bare. The silica was first noticed in a large mound, but further investigation shows that it exists just below the surface of the ground over a large area, and that there are enormous quantities of it.

The whole of the ground in the neighbourhood of the silica deposit is intersected with hot springs, and there are several large hot mud beds, upon which it is not advisable to walk, as they appear to be of considerable depth and the mud is boiling hot. The mud consists of China clay intermixed with sulphur, and small quantities of iron oxide, and probably has a bed of silica underlying it. The peculiarity of the ground is that the upper layer consists of iron oxide, although it is at some places covered with a loose sandy soil in which scrub-like vegetation flourishes. Below the layers of iron oxide, which varies in depth from 6 ins. to 2 or 3 ft., there is a layer of kaolin, which, although very plastic, is of a slightly greyish-green colour, owing to the presence of iron oxide and sulphide. This kaolin layer varies in depth from 1 ft. to 2.5 ft. The analysis of the kaolin is as follows:—

SiO ₂	..	..	..	..	44.61
Al ₂ O ₃	..	..	..	..	39.88
Fe ₂ O ₃	..	..	..	..	0.75
CaO	..	..	..	..	1.16
MgO	..	..	..	..	0.32
H ₂ O	..	..	..	..	13.18
					<u>100.10</u>

On removing the kaolin a deep bed of pure white silica is found. The silica varies in character from soft blocks, which have much the same appearance as blocks of kaolin, to hard glassy veins or lumps, and in many parts is found as a fine flour-like product.

The silica is white and of great purity. Taking the silica mound as the centre, the silica deposit dips gently beneath the soil, so that several hundred yards from the mound it is necessary to dig deeper, and further away deeper still, in order to reach the silica. In one place, just at the base of the mound, a pit 30 ft. deep has been sunk. The overburden here was less than 2 ft., and at that depth pure silica was found. It is of a granular form, and keeps this characteristic until a depth of 22 ft. has been reached, when a vein about 2 ft. thick of milk-white glassy silica is encountered. Below this again the granular silica continues until a depth of 30 ft. is reached, when it still shows no signs of ceasing, and probably extends to a very much greater depth.

About 100 ft. to the right, and also 100 ft. to the left, of this pit silica as fine as flour and of a pure white colour was encountered on digging down about 3 ft. Further

away it was necessary to dig about 6 ft. before reaching the silica.

It should be mentioned that the whole of the mound is covered with ferric oxide, below which is kaolin, and the rest of it appears to consist of pure silica, some of it in blocks and some in powder, and often blocks are embedded in powder.

The following is the analysis of samples of silica taken at different depths from the pit:—

	6 ft.	22 ft.	30 ft.
SiO ₂	97.12	94.35	99.08 ¹
Al ₂ O ₃	0.39	1.24	0.36
Fe ₂ O ₃	0.27	0.32	0.24
CaO	0.60	0.59	0.15
MgO	0.24	0.40	0.27
H ₂ O (hydration)	1.20	3.80	—
	99.72	100.70	100.10

These analyses show that the silica is of an homogeneous quality. Altogether about forty analyses were made, which show the silica in other parts of the district to be of an equally high quality. In some cases the Fe₂O₃ did not exceed 0.1 per cent.

About 200 yards from the silica mound there is a very interesting little geyser which spouts boiling water with clockwork regularity every fifty minutes. This water is extremely brackish, and its analysis is interesting, as it contains a particularly high potash content. Whether the contents of the water are constant I am unable to say, as only one sample was brought back, which gave the following analysis:—

KCl	..	..	..	23.50
NaCl	..	..	..	62.00
CaCl ₂	..	..	..	12.00
MgSO ₄	..	..	..	0.90
Fe ₂ O ₃ , Al ₂ O ₃	..	..	..	0.60
SiO ₂	..	..	..	0.91
				<u>99.91</u>

I am inclined to think that the analysis of the water which shows it to contain 0.91% of silica gives an indication that the silica has been formed by the action of the carbonic acid of the air upon it. In some parts, where on digging down the silica was very moist and too hot to handle, the upper surfaces were covered with gelatinous silicic acid.

Probably the high potash content of the geyser water points to beds of felspar lying very likely at great depths below the surface. Here the water at a very high temperature under great pressure is continually decomposing the felspar with production of kaolin and silica. It is also quite possible that the water may also contain considerable quantities of carbonic acid, and this, acting with the hot

¹ Ignited before analysis.

water under pressure, would cause the decomposition of the felspar to be comparatively rapid. The iron oxide will probably be produced by the decomposition of silicates containing oxide of iron, bauxite for example.

The extraordinary part about the deposits, however, is the uniform overburden, first of a layer of iron oxide and below this of kaolin before the silica is reached. Owing to the presence of sulphur the whole district has a distinct smell of sulphuretted hydrogen. The quantity of sulphur deposited is, however, very slight.

SOIL TEXTURE.

By C. T. GIMINGHAM, F.I.C.

IN the study of soils and of the numerous important problems connected with soil fertility, the first essential is to have an accurate and uniform system of classification, in order to compare and differentiate soils possessing varying characters. It has been abundantly proved that the *chemical* composition of soils does not form a practically useful basis for such a classification; and reliance is now always placed upon the physical or mechanical composition. This is ascertained by determining the proportions of various arbitrarily-chosen grades of particles in the soil; the methods are entirely empirical and therefore only of value so long as precisely the same details are rigidly adhered to in every case so that the figures obtained are all strictly comparable. The method employed in this country was worked out by Hall and is recommended by the Agricultural Education Association; it involves the separation of the coarser particles by sieves of standard mesh and the finer ones by subsidence in water for various periods, care being taken that all compound aggregates of particles are broken up. The figures obtained represent the ultimate mechanical composition of the soil, and considered in conjunction with the proportions of organic matter and of carbonates present, give information of the greatest value. The relations of the soil towards water, its suitability for one crop or another, and, to a very large extent, its agricultural value generally, are determined by the texture; and the texture is, in the end, determined by the relationships between the various-sized inorganic particles, the organic-matter (decaying and decayed vegetable material, etc.) and the carbonates, if any. It is found also—and is indeed a matter of general experience—that the mechanical composition of soils is directly correlated with the geological formations from which they are derived; and from all points of view the mechanical analysis serves as a good basis for the classification of soils.

The interpretation of the results of such analyses needs, however, a good deal of care, and an isolated analysis, unless it happens to reveal some striking peculiarity, is not likely to be of much practical value without a knowledge of the type to which the soil belongs. Hence the importance of the systematic soil surveys, now being carried out in various parts of the country, of which Hall and Russell's "Agriculture and Soils of Kent, Surrey and Sussex," published by the Board of Agriculture, is the prototype. These will gradually provide material giving information as to the normal character of the various soil types; and with such details available for comparison, it becomes possible for the soil-analyst to interpret the results of single analyses with some degree of confidence.

It is important at the same time to realise that the

determination of the ultimate mechanical composition, valuable as is the information it supplies, does not give a picture of the condition of the soil *in situ*; it has reference only to the inherent properties of the soil and takes no account of the effects of particular methods of treatment, or of the nature of the water supply, or of the prevailing climate. These factors cannot be overlooked, and the results of analysis can only be discussed in a useful manner with a full knowledge of local conditions, for soils of similar composition will behave very differently under different sets of conditions. Moreover, deductions drawn from the mechanical analysis may have to be greatly modified in certain cases. For example, the presence of a large proportion of organic matter or of calcium carbonate in the soil will to a very great extent mask the properties ordinarily manifested by the various grades of particles. The writer is acquainted with certain soils which, in spite of the fact that they contain a very high proportion of the finest-grained particles ("clay") none the less possess a very loose and open texture, due to the presence of over 20% of organic matter, which entirely obscures the normal effect of the "clay." As far as the physical properties are concerned, the mineral matter in such soils plays only a secondary part, and the mechanical analysis by itself gives no clear indications.

It is well-known that the texture of the soil often varies considerably from field to field quite apart from any change in the soil type; and such differences are by no means always to be explained by the results of mechanical analysis. This is especially true of soils permanently occupied by grass, and, indeed, mechanical analysis does not appear to give such valuable information in working with pasture soils as it does in the case of arable soils. In pasture soils, where the surface receives a minimum of disturbance, there is always an accumulation of organic matter to a greater or less extent, which no doubt in many cases exercises a controlling influence on the physical properties. An example of such differences in physical condition and texture which cannot be accounted for by referring them to the ultimate composition of the soils, is to be found in certain pastures on the lower lias formation in Mid-Somerset (*see* Gimmingham, "The Scouring Lands of Somerset," *J. Board Agric.*, 17, 529; also "Variation in Pastures," *Sci. Prog.*, July, 1912, 133). Here very marked differences in the feeding value of closely adjoining pastures are to be noted in certain places, and these can be correlated with differences in the surface soils of the fields, in some cases quite obvious, but in others only to be realised by the definite but somewhat indefinable difference in the "feel" to the foot on walking over the ground. The mechanical analyses show the soils to be very similar and of the same general type. There is, however, a higher proportion of organic matter in the good soils, and it is to its influence on the nature of the compound particles that the observed differences must be set down. Other similar cases could be quoted, and there is at present no satisfactory method for expressing such differences.

In this connection it has been suggested that a useful figure might possibly be obtained by determining the percentage shrinkage of soils on drying, and some recent experiments in this direction have given very interesting results. In the *West Indian Bulletin*, 1912, 12, 1, Dr. Francis Watts and his colleagues record the results of attempts to measure soil shrinkage. A method capable of a considerable degree of accuracy was worked out depending on the measurement from day to day of the distance between two pins inserted into a brick made by

kneading the dry soil with a certain proportion of water. Various precautions were taken in kneading the sample uniformly and in securing a uniform degree of plasticity before making up the brick.

The degree of accuracy of the method having been ascertained, attempts were made to see whether any relationship existed between the percentage shrinkage of soil (and subsoil) and its suitability for growing cacao, a crop for which the physical nature of the soil appears to be the limiting factor in production. The results are somewhat remarkable, the correlation between the percentage shrinkage of the soil and the condition of the cacao being very striking. It was found possible, indeed, to suggest provisional standards of shrinkage for soils on which it is proposed to plant cacao, which have proved of direct value as a clue to the suitability of the soil for this particular crop.

The methods employed, admittedly giving only approximate results, have proved of direct practical importance in this case; they are probably susceptible of improvement, and if satisfactorily standardised should yield most useful information with regard to the cohesive properties of soils which cannot be directly inferred from the figures of the mechanical analysis.

OILS, FATS, AND MILK PRODUCTS.

By E. RICHARDS BOLTON and CECIL REVIS.

IN our last article we had occasion to point out how great a revolution in the fat and soap industries the enormous development of processes for the hydrogenisation of oils was likely to effect. The past month has seen an internal revolution in connection with that industry, which will most certainly tend to the still further development of these products. A decision given by Mr. Justice Neville in the Chancery Division has made it practically certain that the very numerous patents which have been taken out for achieving the hardening of oils are likely to hold good in law, and it would appear, therefore, from this decision that hardened fats may be made without infringing the Normann patent, and consequently a rapid development will probably take place. The reports on this case are worthy of the attention of those interested in this matter.

Some of the difficulties connected with the analysis of these hardened oils have been investigated by Kreis and Roth (*Zeits. Untersuch. Nahr. Genussm.*, 1913, 25, 81). They point out that the nitric acid-resorcinol test for seed oils is not rendered nugatory in the case of arachis, cotton seed and sesamé oils, though the colour is somewhat different to that obtained with the untreated oil. They have also worked out a useful method for detecting arachidic

acid in hardened fats, which is very acceptable—seeing that in the ordinary Bellier's test, as would be expected, an unsurmountable difficulty arises on account of the production of large quantities of glycerides of high molecular weight during the manufacture of the fat.

Some extremely interesting results on the melting-point of fats have been obtained by Grün (*Berichte*, 1912, 45, 3691). Fluid and solid modifications of the di- and tri-glycerides of lauric acid have been prepared which evidently undergo molecular changes and alteration in melting point on standing, and the fluid modifications possess molecular weights very much lower than would be expected theoretically. The many investigations which are being carried out at the present time for the purpose of elucidating the composition of the natural glycerides, though they have not yet led to any very definite results, are all tending to throw light upon an obscure problem, the solution of which will be most useful. Holde, in an immediately succeeding paper (*loc. cit.*, p. 3701), again expresses his opinion that in fats which are liquid at ordinary temperatures the solid fatty acids are present as solid solutions of glycerides of solid and liquid fatty acids and not as tri-glycerides.

Among analytical methods a novel process for the detection of adulteration of linseed oil has been put forward by Elsdon and Hawley (*Analyst*, 1913, 38, 383). While not being quite convincing from the figures given, the method is well worthy of trial, the chief difficulty in connection with it seeming to lie in a possible incompleteness of extraction. A critical investigation of Chinese wood oil has been carried out by Chapman, which has resulted in a much clearer knowledge of the reliability of the various tests which have been brought forward from time to time for the examination of these oils. He has also drawn attention to the very necessary discrimination which is to be made between Chinese and Japanese wood oils, as these have been quite commonly confused.

A bulletin published by the U.S. Department of Agriculture from the Bureau of Animal Industry, No. 166, records an investigation carried out by Doane on the digestibility of cheese which has led to some rather surprising results. It has been found that the digestibility of the protein of Cheddar cheese is from 90% to 100% of the total present and that this digestibility is just as good in the case of the freshly made cheese as when fully ripened. This is certainly somewhat contrary to what might be expected, and it is also noteworthy that in the case of Camembert and Roquefort cheeses the protein is less digestible than in Cheddar, in spite of the more profound degradation which the protein undergoes in the former varieties.

NOTES OF MEETINGS.

CHEMICAL SOCIETY.

June 5th and 19th, at 8.30 p.m. Ordinary Meetings.

* * *

SOCIETY OF PUBLIC ANALYSTS.

June 4th, at 8 p.m.

* * *

SOCIETY OF CHEMICAL INDUSTRY.

LONDON SECTION :—June 2nd, at 8 p.m.

- (1) "Precipitation in Aqueous and Colloidal Systems," by W. P. Dreaper.

- (2) "The Preparation of Alloys," by W. R. Hodgkinson.
(3) "Some Experiments on the Theory of Electric Tanning," by Eric K. Evans and Ulick R. Evans.
(4) "An Illustration of the Partial Pyrite Process," by W. R. Scholler.

* * *

THE ROYAL INSTITUTION.

June 3rd, Professor T. B. Wood, "Production and Utilisation of Wheat in England," at 3 p.m.

June 5th, Professor W. J. Pope, "The Structure of Crystals," at 3 p.m.

EQUIPMENT OF CHEMICAL LABORATORIES FOR TEACHING PURPOSES.

By J. B. COLEMAN, A.R.C.S., F.I.C. Head of the Chemical Department, South-Western Polytechnic, Chelsea.

THIS article contains a description of the general fittings of a chemical laboratory as suggested by experience. The paper includes a somewhat detailed account of the fitting-up of the laboratory benches, but does not attempt to describe the ordinary apparatus and re-agents employed, as the latter vary, more or less, with the views of each teacher.

In most large institutions there are provided separate laboratories for elementary, general, and organic work.

Since the general laboratory fittings are similar the descriptive matter has been arranged under two headings:—

1. The general arrangement and position of the benches, tables and draught-chambers, and the position and connections of the gas, water and waste services.

2. The special arrangement of the laboratory bench and its accessories.

GENERAL ARRANGEMENT OF THE LABORATORY.

In designing the general fittings of a chemical laboratory, the following considerations should be borne in mind:—

- (a) Ample bench-room for each student:
- (b) Easy access to the benches:
- (c) Provision of central-draughts and such other arrangements that will reduce walking about to a minimum:

(d) Facilities for reading or for writing up notes without interfering with bench experiments.

The outline-plan of a chemical laboratory (Fig. 1) shows a convenient arrangement of benches, draught cupboards, etc., but certain modifications will be necessary in special cases.

The benches are arranged in six blocks of four benches each, thus accommodating twenty-four students at one time. This arrangement of the benches allows plenty of space for each student and excellent supervision by the teacher.

Although this system occupies more room than the older method of placing the benches in rows, it is far more convenient.

The central-draught from each block of benches is conveyed downwards and then along and under the floor in lead-

lined (or stoneware) flues, which are exhausted by an electric fan. The mechanical system of exhaustion is preferable to any other, as it is uniformly reliable.

The gas and water supply should be of good pressure and adequate.

The waste from each bench, after being trapped (see description below), is conveyed to a central lead-lined (or stoneware) trough which is open above. The trough runs under the floor in an accessible position and is finally connected with the main drains. The troughs are so placed that they may be inspected and the sediment removed from time to time.

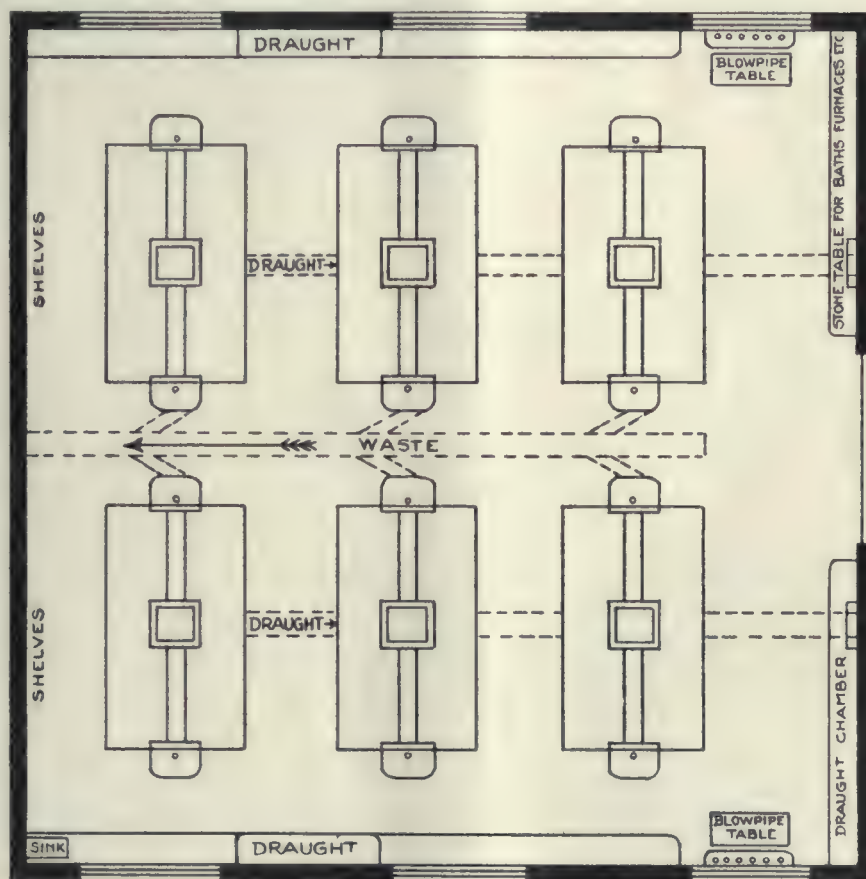


FIG. 1.

The draught chambers, which should be commodious, have slate bases, and are lined at the back with white tiles. The exhaust pipe has two openings, one near the bottom and the other near the top of the chamber. The air may thus be extracted either by means of the lower or the upper opening, or by both simultaneously; thus

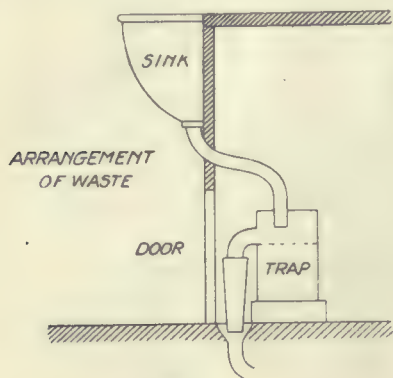


FIG. 2.

adapting the exhaust to the height at which the products are given off.

A stone or slate table supplied with gas, water, steam and waste holds the necessary baths, steam-ovens, distilling apparatus and furnaces. A large hood, connected with the draught-flues, covers the whole of this table.

Long teak tables run along each side of the room, which are used for writing, reading, and other purposes.

Two blowpipe tables are provided for glass-



FIG. 3.

working, etc., and shelves and cupboards are arranged for storing re-agents and apparatus.

A blackboard is also provided which is useful for demonstration purposes.

SPECIAL BENCH ARRANGEMENTS.

The following conditions should be observed in designing the working benches:—

(a) Ample room *around* the working benches.



FIG. 4.

(b) Efficient and ample water, gas, and waste arrangements for each student.

(c) A central draught-hood or cupboard for each pair of students.

(d) Storage room in the shape of cupboards and drawers under the working bench.

(e) In special cases, the supply of steam, hydrogen sulphide gas and electric current.

Illustration of two types of benches are shown in Figs. 3 and 4.

The general arrangement is similar in each case, but they differ in detail.

It will be seen that the benches, which are of teak, are arranged in blocks of four. The sinks are attached to the ends of the benches, not let into the bench-tops; this plan enables the student to utilise the whole of the working space. The position of the sink also keeps the bench much cleaner. The sinks are capacious and are 10 ins. deep: they carry a false bottom of perforated teak, which diminishes breakages and prevents solids being carried through to the waste.

The waste liquids, after passing through the sink, should be adequately trapped. A good stoneware trap serves the double purpose of retaining any solid matter and of diluting acid liquids, so that they do not act greatly upon the leaden or other waste-service.

A convenient trap is shown in Fig. 2. It is connected by means of a flexible rubber-tube with the leaden waste-pipe. The trap is easily disconnected and should be cleansed from time to time.

The water supply should be ample; in the bench

shown in Fig. 4, five taps are supplied for each pair of students, two large screw-taps for filter-pumps or when a large supply of water is needed, and three plug-taps for ordinary use and for condensers.

The gas supply also should be sufficient: in the bench (Fig. 3) one distributor is supplied to each student; each distributor contains one upright cock fitted with a bat-wing burner for glass-bending and two horizontal taps for use with Bunsen or other burners.

The central draught arrangements in both types of benches (Figs. 3 and 4) are similar, except that in Fig. 3 the arrangement is detachable and in the diagram has been removed. The arrangement consists of a lead-lined wooden (or stoneware) flue rising from the horizontal floor-flue to a height of about 20 ins. above the bench-top. Two hoods 15 ins. in diameter fit into the upright flue, so that one hood serves for two students. The hoods are made of enamelled iron and when fitted are 12 ins. from the bench-top. The hoods are placed in their sockets when required, the openings being fitted with wooden plugs when not in use.

In place of hoods, small glazed cupboards, fitted with doors, may be substituted; this plan is advisable when sulphuretted hydrogen gas is supplied to each bench, but for evaporation of corrosive liquids and other minor operations, the hoods answer admirably and do not occupy so much bench room.

The illustration (Fig. 3) shows a type of bench suitable for elementary work. To hold what few general re-agents are required, a row of white tiles set in a wooden bead, is seen in the centre of the bench. The central dark square is a block of wood covering the draught flue, when not in use. Where the central draught is needed the plug is removed and a flue-pipe carrying two heads is placed in position.

For organic work a similar bench may be used, except that a steam service is added and the centre of the bench is occupied by a shallow leaden-waste connected with the sink-waste.

The illustration (Fig. 4) shows the arrangement of a bench for general and analytical use. In this type of bench central shelves for re-agents are shown and the central draught arrangements are fixed.

Detection of Alkaloids.—Dr. Dobbie has drawn attention to the value of the study of adsorption spectrum of the alkaloids as a method of detection and estimation.

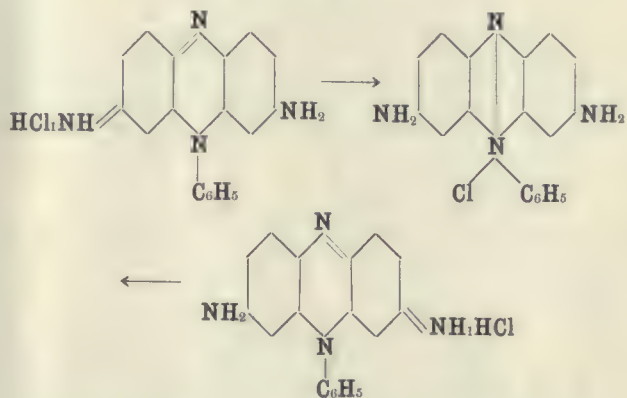
The adsorption occurs in the ultra-violet end of the spectrum, and it is necessary to use a source of light rich in ultra-violet rays, and that the prisms and lenses used should be made of quartz. Alkaloids have very characteristic photographic spectra, which readily distinguish them from one another, except when they are very closely related. One 500th of a grain of strychnine gives a clearly defined spectrum. One great advantage is that the solution which is required for this test can be afterwards subjected to a further chemical examination.

NOTES ON RECENT THEORY AND PRACTICE.

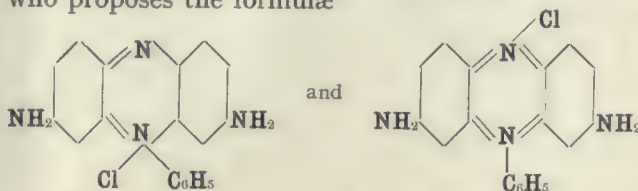
By HERBERT H. HODGSON, M.A., B.Sc., Ph.D.

THE following notes are intended to afford a rapid survey of chemical research pointing out items of exceptional interest only, and setting forth to some extent the main lines of current chemical progress.

The question of constitution, particularly in the case of dyestuffs, is one upon which workers are ever engaged, and in this connection a stimulating paper by Balls, Hewitt and Newman deals with the fluorescence of safranin, which they ascribe to a double tautomerism taking place, viz.:—



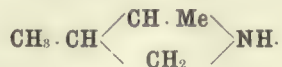
Such a scheme has been disputed by Kehrmann, who proposes the formulæ



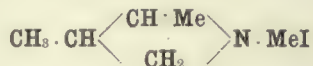
on the ground that both amino-groups may be displaced by hydrogen in one and the same operation. The previous authors, however, find that in acid of medium concentration only one amino-group can be diazotised, and to effect the diazotisation of the second amino-group concentrated acid must be employed. Since, therefore, safranin behaves as a mono-, di- or tri-acidic base, according to the concentration of the acid used to form the salt, arguments based on the diazotisability of an amino group in concentrated acid solution by no means prove that the amino-group is also present in the non-acid salt. Details as to methods for obtaining experimental evidence on the above point are given, and the conclusion is drawn that the data in favour of a continuous or intermittent para-quinonoid structure of the molecule are unanswerable.

That synthetic rubber investigation is receiving attention may be gathered from the patent literature. There, methods for the preparation of isoprene continually appear, among which may be cited two of the Bayer Co., viz., one from methyl-iso-propenyl carbinol, $\text{CH}_2\text{CMe}\cdot\text{CH}\cdot\text{MeOH}$, merely by heating it

slowly to 130—150° C. with a dehydrating agent such as oxalic acid, zinc chloride, potassium hydrogen sulphate, etc.; and a more complicated process starting from keto-methyl-butanol, $\text{CH}_3\text{COCHMeCH}_2\text{OH}$. The latter when converted into the oxime and then reduced yields $\text{CH}_3\text{CH} \cdot \text{NH}_2 \cdot \text{CH} \cdot \text{MeCH}_2\text{OH}$, which, when condensed by halogen acids, yields 2'3 dimethyltrimethylenimine,



On exhaustive methylation, etc., 2'3 dimethyltrimethylen dimethyl ammonium iodide,



is formed, which, by the action of silver oxide, furnishes the quaternary base, and the latter on distillation is converted into dimethyl $\alpha \cdot \beta$ -dimethylallylamine. This, after conversion into the quaternary ammonium iodide, gives isoprene with alkali or alkaline earth hydroxides.

The Badische Co. drop α -dimethylallene on to strongly heated aluminium oxide, preferably under a pressure of about 20—30 mm., and obtain pure isoprene.

Conditions of reaction for the improvement of yields form an infinite opportunity for the patentee, and in this direction we find an interesting communication by Knoll & Co. illustrating the versatility of iodine, which, when present in the fusion of certain organic compounds with sulphur, exerts a most favourable influence on the course of the reaction, diphenylamine derivatives being excepted. The Badische Co., too, have found that whereas the yields of pinacone from the reduction of acetone by sodium are unsatisfactory, yet they become valuable when the solvent medium is a liquid indifferent to sodium such as ether.

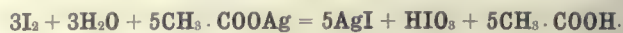
Hans von Liebig raises the interesting question of solvent action in medicinal and plant chemistry. Here methyl and ethyl alcohols are principally used under the assumption that they are, chemically inert. In certain cases Liebig finds the alcohols to exert both an hydrolysing and etherifying action.

The Grignard reaction has been carefully studied by Jolibois, who finds that in preparing $\text{Et} \cdot \text{Mg} \cdot \text{I}$ by the interaction of Mg and EtI in dry ether, if the whole of the ethyl iodide is present at the start a yield of only 41% is obtained, together with an evolution of ethane and ethylene. If, on the other hand, the EtI be added drop by drop as the magnesium dissolves, the yield increases to 91%.

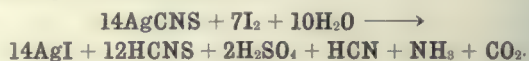
The action of sunlight forms the subject of an interesting paper by Gibbs, who finds that solutions of para-quinone in methyl alcohol become formaldehyde and quinol. Now methyl alcohol is oxidised by hydrogen peroxide, chiefly to formaldehyde, temperature being an important factor in the speed of the reaction. Here, then, is evidence for the production of H_2O_2 by the action of sunlight upon water and oxygen.

The action of halogens on silver salts has been

examined by Normand and Cumming, who find that the reaction products are an insoluble silver halide, an acid, and one or more oxidation products of either acid or halide, e.g.,



The reactions are sometimes complicated by secondary oxidations, e.g.,



These oxidation reactions are much more marked with chlorine and bromine than with iodine, probably on account of the greater oxidising power of hypochlorous and hypobromous acids as compared with iodic or hypoiodous acids. The main product by treating silver cyanate with iodine was carbamide, this probably resulting from a secondary decomposition of cyanic acid. Bromine and silver cyanite yield ammonium bromide, carbamide, cyanuric acid and a little nitrogen. The formation of carbamide raised the question of the decomposition of aqueous cyanic acid, and experimental evidence pointed to the conclusion that cyanic acid decomposes in three different ways according to conditions. In concentrated solution cyanuric acid is the main product, probably by polymerisation of non-ionised cyanic acid molecules. Acids appear to decompose cyanic acid according to the scheme:—



In dilute solution cyanic acid decomposes itself according to the above equation until all the hydron has been used up. The ammonium ions and the remaining cyanate ions interact to form carbamide. The whole reaction then appears to be:—



In colloidal chemistry Posnjah concludes from experiments on the swelling pressure that the swelling of colloids is in the nature of a capillary process rather than of a simple solution phenomenon.

Among items of practical interest may be noted the use of arsenic xanthate in analysis. Tarugi has demonstrated the quantitative precipitation of arsenic by potassium xanthate to form $\text{As}(\text{S} \cdot \text{CSOEt})_3$, a substance insoluble in hot or cold water, but soluble in benzene, carbon bisulphide, and carbon tetrachloride.

Hempel and Vater find that the adsorptive power of animal charcoal for all gases is considerably greater than that of cocoanut charcoal, the best results being obtained with a sample prepared at 600° C.

A'umina, prepared by igniting the hydroxide at a low temperature, has been found by Johnson to be a very effective drying agent, much superior to calcium and zinc bromides, zinc chloride and sulphuric acid.

Guareschi has proposed a very sensitive test for bromine. He finds that a trace of bromine gives an intense violet-blue coloration with Schiff's reagent, while iodine gives virtually no colour and chlorine yields nearly a brownish yellow or red tint. The reaction is hindered by nitrites.

MOLECULAR PHYSICS.

By J. A. CROWTHER, M.A. (Fellow of St. John's College, and Demonstrator in Physics in the Cavendish Laboratory, Cambridge.)

CHAPTER IV. (*continued*).

THE NEW METHOD OF ANALYSIS.

It will be noticed that the lines decrease in intensity as the number of charges carried is increased. This is always to be observed on the photographs, and is a fact which sometimes helps us to the right interpretation of a doubtful line in a photograph. For example, if the line indicating a mass of 20 on Fig. 12 had been brighter than the Argon line (40) we should have been able to say definitely that it was due to atoms of Neon, and not to Argon atoms with a double charge.

The plates so far described were all taken using large magnetic fields in order to obtain a suitable dispersion of the heavier atoms. The last plate of the series (Fig. 14) was taken with a smaller magnetic dispersion, and shows the lines due to some of the lighter elements. It is of peculiar interest at the present moment, as it is one of the photographs which shows the mysterious line due to particles for which the ratio of the mass to the charge is exactly three times that for the singly charged hydrogen atom. On this account it may perhaps be of interest to give the actual measurements made on this plate (Table IV.). The first column of the

TABLE IV.

Gases evolved from Platinum bombarded with Cathode rays for 6 hours. (See Fig. 14.)

d m.m.	m/E .	Probable cause of line.
27.0	1.00	H + Hydrogen atom.
19.1	2.0	H ₂ + Hydrogen molecule.
15.6	3.0	? Unknown element.
7.8	12	C + Carbon atom.
6.7	16	O + Oxygen atom.
5.8	21	Ne + Neon atom (20).
4.8	32	O ₂ + Oxygen molecule.

table gives the actual measurements of a common ordinate of the different parabolas, the second column the corresponding values of m/E , the ratio for the hydrogen atom being taken as unity.

The gas used in the experiment was a sample of that mysterious gas which is evolved in considerable quantities when any metal is heated, or better still, as in the present case, bombarded with cathode rays in a vacuum tube. That gases were evolved under these circumstances had been known for some considerable time, but their analysis had not been previously effected. As will be seen from the table, the gas consists principally of hydrogen, but helium and neon are also present; while the plate also shows traces of carbon and oxygen, probably due to impurities in the apparatus.

In addition to these known substances there is

also very clearly marked a line, the third from the top of the plate, which cannot be assigned to any known element or compound. There was at first the possibility that it might be due to a carbon atom carrying four elementary charges, but this hypothesis was found to be untenable. In the first place the line under consideration is much brighter than that due to the singly charged carbon atoms, while we have seen that on a given plate the curves due to multiply charged atoms are invariably fainter than those due to atoms of the same substance having a single charge. In the second place, when precautions were taken to exclude carbon compounds from the apparatus the carbon line (12) completely disappeared, while the line 3 remained as bright as ever.

Only two possibilities remain. The line may be due to a previously unknown element of atomic weight 3, or it is due to a hitherto unknown modification of hydrogen H₃ corresponding to ozone. If the latter is the case, the substance has some quite unexpected properties, as it is certainly not destroyed by sparking with excess of oxygen. Professor Sir J. J. Thomson is still actively pursuing his experiments on this substance, and some very interesting results may be expected. Until these experiments are completed it would be premature to venture any further opinion as to the real nature of this new gas.

Another parabola which is found when the gases from liquid air residues are introduced into the tube suggests interesting possibilities. This is a line giving a value for m/E equal to 22. This might possibly be a molecule of carbon dioxide (44) with a double charge, but from the fact that it appears only in these mixtures of the rarer atmospheric gases, and that it is quite well marked even when the CO₂ and CO lines are absent seems to point to it being a new compound NeH₂ of neon and hydrogen.

A few further points of interest in the photographs may be noted. The bright central spot shown in all the figures is due to the particles which have lost their charge during their passage through the long copper canal tube, and are therefore undeflected by any combination of electric and magnetic fields. The atoms of some elements have such a strong attraction for the surrounding negative electrons that they actually take up more of them than would be sufficient to neutralise the original positive charge. They thus enter the deflecting fields with a negative instead of a positive charge, and so give rise to parabolas in the opposite quadrant to those due to the positive particles, but giving, of course, the same values for m/E . At least two of these "negative" parabolas appear on Fig. 13. Oxygen and the halogens if present in any quantity almost invariably give these negative curves. Strangely enough hydrogen, which is generally

reckoned among the more electro-positive elements, also frequently shows the same effect. It has never been found with nitrogen or helium.

We have so far only been considering the relative values on the ratio m/E for the different particles. By measuring the dimensions of the different parts of the apparatus and calculating the actual values of the constants k_1 and k_2 , the absolute value of this ratio for any given parabola can be deduced. Such a determination was made by Professor Sir J. J. Thomson, and it was found that the absolute value for the outermost parabola of all was almost exactly 10^{-4} . We have seen that this is the value of the ratio for a hydrogen ion in solution or a hydrogen atom carrying a single charge. The particles with which we have been dealing are therefore actual atoms and molecules of the substances in the discharge tube, as we have tacitly assumed in the foregoing pages.

We have now described in some detail the principal features of the new method of molecular analysis. Its importance can hardly be exaggerated. In the first place it enables us to detect with certainty the presence in a gaseous mixture of far smaller quantities of an element than could be accomplished by any other method known to science. Professor Thomson has given the following striking illustration of the delicacy of the method. It was found that the photographs taken with atmospheric argon in the apparatus always showed the helium line faint but quite distinct. In this particular experiment the volume of the discharge tube was about 2 litres, and the pressure of the gas in the tube $1/300$ m.m. of mercury. The gas experimented on would therefore have had a volume of about $1/100$ c.c. at atmospheric pressure. This is approximately the quantity of argon in 1 c.c. of air at atmospheric pressure. We are thus able to detect the helium present in a single cubic centimetre of air. According to the determinations of Professor Ramsay this amounts to no more than four millionths of a cubic centimetre.

The new method has the further advantage over spectroscopic analysis that it gives directly the atomic or molecular weight of the substance under experiment. Thus the photograph of Fig. 14 not only reveals the existence of a new gas but gives at once its molecular weight.

Lastly, and this is perhaps most important of all from the point of view of an intimate study of the modes and methods of chemical combination and decomposition, the time taken for each single particle to register its presence and mass is exceedingly minute. A very moderate value for the speed of the positive particles is 10^8 cms. per second (about 620 miles per second). Their path in the discharge tube is not more than 50 cms. in all. Thus a particle when caught by the discharge will register itself on the photographic plate in considerably less than one millionth of a second.

We might therefore reasonably expect to find on the photographs curves corresponding to temporary combinations of atoms so unstable that their whole period of existence is not greater than one millionth of a second, if any such combinations are formed in

the discharge tube. Thus in the case of chemical reactions taking place within the discharge tube we might expect to find on the plate traces not merely of the stable products of the reaction but also of any intermediate stages occurring in the course of the reaction. The field thus opened up for an intimate study of the mechanism of chemical reactions is illimitable.

Though little has as yet been accomplished along these lines, the experiments already made show that this expectation is not unfounded. As a very simple illustration of the application of the method we may take the case of phosgene, COCl_2 . When this was introduced into the apparatus the photographs showed that, in addition to the molecules of undecomposed phosgene (99), the carriers of positive electricity were molecules of carbon monoxide (28) and atoms of chlorine (35.5). The lines due to single atoms of carbon and oxygen were very faint indeed, thus showing that the decomposition of the compound by the discharge consisted of the separation of the chlorine atoms from the CO molecule, the bond between the carbon and oxygen atoms remaining intact.

This is a simple case where the results obtained might easily have been predicted. Another interesting case is that of methane, CH_4 . When this gas is subjected to the discharge a group of five lines appears on the photographic plate, indicating the presence of particles having masses 12, 13, 14, 15 and 16 times that of the hydrogen atom. These correspond to particles having the composition C, CH, CH_2 , CH_3 , and CH_4 respectively.

We have been dealing so far with the many advantages of the method. Some of its limitations should perhaps be pointed out. In the first place the substance to be experimented on must be either gaseous or capable of exerting a vapour pressure at ordinary temperatures. A more important defect, and one which is shared by the spectroscopic method, is that an element may be present in considerable quantity in the discharge tube without producing a corresponding trace upon the photographic plate. Thus, although many metals have compounds sufficiently volatile for the purpose of the experiment, mercury and nickel are the only metallic elements which have so far been detected by the method.

One word may be added as to the relative intensity of the different lines on a given photograph. It is found that in general this is far from representing the actual proportion of the particles in the stream having masses corresponding to the different lines. For some reason at present unexplained, a given number of atoms of a light element produce far greater effect on a photographic plate or willemite screen than an equal number of the atoms of a heavier element. Thus the parabola corresponding to the hydrogen atom will often be the most intense line on the plate when the amount of that element present forms less than 1% of the contents of the tube.

This has been very clearly demonstrated by Sir J. J. Thomson by substituting an electrical for a photographic method of detecting the positive

particles. It must be remembered that as all the particles with which we are dealing carry an electric charge they can be measured by collecting them in a Faraday cylinder in the way described for the α -particles in the preceding chapter.

To carry out the experiment a brass plate B (Fig. 15) was substituted for the glass screen Z of Fig. 9. If the brass plate is covered with powdered willemite a series of bright parabolic curves will of course appear upon it when the tube is running somewhat as indicated in Fig. 15a, where three such curves are shown. If a slit SS is cut in the brass plate so as to coincide with one of the parabolas the particles forming this parabola will pass through the slit and can be collected by a Faraday cylinder F (Fig. 15b) placed immediately behind it. As explained in Chapter III., the rate of charging up of an electrometer connected to the Faraday cylinder will be proportional to the number of particles entering the latter per second, that is to say, to the relative number of molecules in the positive rays which have a mass corresponding to that indicated by the parabola coinciding with the slit SS.

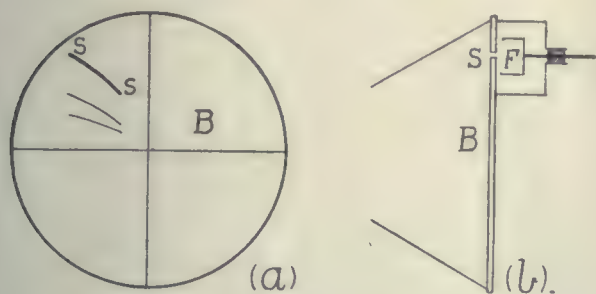


FIG. 15.—APPARATUS FOR THE ELECTRICAL MEASUREMENT OF THE POSITIVE RAYS.

If the slit could be made to coincide successively with each of the different parabolas indicated by the glowing willemite, the relative rates of deflection of the electrometer for the different positions would be proportional to the number of particles of corresponding mass in the positive rays from the discharge. The experiment can be performed much more conveniently without moving the slit by varying the intensity of the deflecting magnetic field, H . If this is increased it can easily be seen that the corresponding magnetic deflections of the particles will also be increased and the various parabolas will move outwards from the centre of the screen. In this way each of them in turn can be brought to coincide with the parabolic slit SS. It can easily be seen from equations (a) and (b) that if the other conditions of the experiment remain the same the value of m/E for a given set of particles is proportional to the square of the strength of the magnetic field necessary to deflect them to a given position. Thus from the various rates of deflection of the electrometer corresponding to different values of the magnetic field we can at once determine the relative number of particles in the beam of positive rays corresponding to definite values of the ratio m/E . In other words, we can determine the relative propor-

tions of the different kinds of atoms and molecules which make up a given beam of positive rays.

On making the experiment it was found that there was practically no movement of the needle of the electrometer connected to the Faraday cylinder except when one of the bright parabolas was made to coincide with the slit. If a fairly narrow slit was used, the appearance and disappearance of a deflection of the electrometer as such a line passed across the slit was surprisingly sharp, and lines quite close together could easily be separated.

Although we can thus perform a quantitative analysis of the beam of positive rays it cannot be assumed without further experiment that the number of atoms of an element in the beam is necessarily proportional to the quantity of the substance present in the discharge tube. Preliminary experiments, however, seem to indicate that this is very approximately the case at any rate for the non-metallic elements. If so, this latest modification of the method of molecular analysis will enable us to carry out not merely a qualitative but also a quantitative analysis of any gas introduced into the discharge tube. The quantitative determination of traces of a gaseous substance too small to be detected by the spectroscope will then have become an accomplished fact.

CHAPTER V.

THE NATURE AND SIZE OF AN ELECTRON.

We must now turn from these triumphs of experimental skill to some theoretical considerations, and discuss briefly the new views of the atom to which they have given rise. It would be idle to pretend that we have as yet any theory of the structure of the atom which absolutely and completely sums up all the known phenomena of Science. The scientific philosophers of an earlier age hoped that at no very distant date they might be able to include in one or more ponderous tomes all that could be known in the realm of physical phenomena. Looking down the long vistas which the new discoveries have so recently opened up, we expect no such immediate end. We are not yet within sight of a mechanical or electrical theory of the universe wherein all the chemical and physical properties of the material universe shall be explicable in terms of the electrons and their motions. Still, while we cannot say that we have such a theory, there are certain sign-posts pointing out the direction in which we may hope for ultimate success. Even now it is possible to construct "models" of the atom which, however crude and insufficient they may be, enable us to link together many most diverse phenomena.

In the realm of science an insufficient, or even a false, hypothesis is better than none at all, and it will be useful to take the best approximation we can devise to serve us as a clue through the labyrinth of experimental facts which we have still to consider. At the same time, it will be well to point out carefully where we are treading the solid ground of

experimental fact and legitimate deduction, and where we rise to the higher but more precarious flights of scientific imagination.

We have seen that electrons are contained in all atoms, and many phenomena lead us to believe that they play a most important part in determining both the chemical and the physical properties of the substance. The question naturally arises, what is an electron? Fortunately to this question also we are able to give some answer. An electron is an atom of electricity free from association with anything in the nature of matter as we know it. It not merely has a charge, it is a charge, and apart from its charge has no existence and no properties, not even that of mass.

The exact proof of this statement has involved long and intricate mathematical analysis. It will, however, be possible, without going at all deeply into these abstruse calculations, to make clear the nature of the proofs advanced, and the experimental evidence upon which they rest.

In the first place, since we have already determined the mass of an electron, we must show that such a moving electric charge will possess mass, a property which we have been accustomed to associate only with what we call matter. The proof follows directly from the ordinary laws of electric and magnetic induction, and was first given by Professor J. J. Thomson, in 1881, many years before the discovery of the electron rendered possible any practical application of the result.

Consider a small sphere charged with electricity of either sign moving through space with a velocity v . We have already pointed out that this moving sphere will be equivalent to an electric current element coinciding with the path of the particle. By the usual laws of electro-magnetic induction this current element will produce a magnetic field, at a distance r from the particle, equal to $ev \sin \theta / r^2$, where θ is the angle between the direction of motion of the particle and the direction of r . Thus, the moving particle is surrounded not only by an electro-static field due to its charge, but also by a magnetic field due to the motion of that charge. It will be seen that this field has its greatest value in a direction at right angles to the motion of the particle, and falls to zero in the direction in which the particle is travelling.

It is a well-known fact that a magnetic field is the seat of energy, the energy in a field of strength H being $\frac{H^2}{8\pi}$ times the volume. The magnetic energy in a small space of volume u at a distance r from our moving charge is thus

$$\left(\frac{ev \sin \theta}{r^2}\right)^2 \frac{u}{8\pi} \quad \text{or} \quad \frac{ue^2 \sin^2 \theta}{8\pi r^4} \cdot v^2.$$

The total energy of the magnetic field surrounding the particle is the sum of the energy in all these little volumes, from the surface of the particle away to infinity. The summation of this quantity does not present any difficulties. It is equal to $\frac{1}{3} \frac{e^2 v^2}{a}$,

where a is the radius of the sphere.

If m is the ordinary mechanical mass of the

particle, the kinetic energy due to its motion will be $\frac{1}{2} mv^2$. In addition to this there is, as we have shown, a quantity of energy due to its charge. The total energy of the moving particle and its charge is thus

$$\frac{1}{2} mv^2 + \frac{1}{3} \frac{e^2 v^2}{a}.$$

If we write this in the form $\frac{1}{2} \left(m + \frac{2}{3} \frac{e^2}{a}\right) v^2$, and compare it with the ordinary Newtonian expression for the kinetic energy of a particle $\left(\frac{1}{2} mv^2\right)$ we see that the particle behaves as if its mass m had been increased by an amount equal to $\frac{2}{3} \frac{e^2}{a}$. This is the extra or "electrical" mass, due to the fact that the particle carries a charge. It is evident that, even if m , the "mechanical" mass of the particle, is zero, the "electrical" mass due to the moving charge will still persist. Thus, even if our electron is a pure charge unassociated with any mechanical mass, it will still have an electrical mass equal to

$$\frac{2 \times (\text{electrical charge})^2}{3 \times \text{radius}}.$$

Since this "electrical" mass is really that of the magnetic field surrounding the particle, it resides not in the particle itself but in the medium surrounding it, that is, in that mysterious fluid which we call the ether. As soon, however, as we attempt to alter the motion of the particle this energy flows into it from all sides, so that, as far as experiments upon the particle itself are concerned, the results obtained are precisely the same as if it resided permanently there.

To make this somewhat novel idea a little clearer we may consider a close and very serviceable analogy, where the mechanism of the extra mass is a little clearer than in the electrical case. If any body is moving through water, or any viscous fluid, it carries with it a certain amount of the liquid through which it is moving. In the case of a sphere, for example, the quantity carried along by the motion of the body amounts to half the volume of the sphere itself. A long cylinder moving at right angles to its own length will carry with it a quantity of fluid equal to its own volume. On the other hand, if it moves in the direction of its own length the fluid entangled is practically *nil*. Thus, in order to set the body in motion with a velocity v , we have to supply to it energy enough to give this velocity, not only to the sphere itself, but also to the mass of fluid which it carries with it. That is to say, if M is the mass of the sphere itself, and M' the mass of the attached fluid, the work done in starting the body is $\frac{1}{2} (M + M') \cdot v^2$.

In other words, the body will behave as if its mass were increased by the mass of the fluid entangled by it. Just as in the electrical case, this extra mass resides in the surrounding medium.

(To be continued.)

Errata.—For "cathode" in Figs. 10, 12 and 13, on pages 162, 163 and 164 respectively, read "positive."

INSTITUTE OF CHEMISTRY BUILDINGS.

WE reproduce on this page an illustration adapted from a coloured sketch from the design of Mr. John J. Burnet, LL.D., F.R.I.B.A., of the new building of the Institute of Chemistry proposed to be erected at the corner of Russell Square and Keppel Street, London, W.C.

The proposed building is in harmony with the simple and dignified Georgian buildings in the neighbourhood, while its high stone base, with brick treatment above broken by a strong stone cornice, bring it into relation with the extension buildings of the British Museum, which are not far distant, and which are due to the same architect. The front is in line with the present houses on the west side of Russell Square, the stone base to Keppel Street being brought forward at the corner towards the square, and terminated by a bracket, on which stands a stone figure of Priestley.

The entrance is on the side front to Keppel Street, and over it is the wide semi-circular-headed feature of the window to the main staircase. In line with this, at the first-floor level, are the large windows of the library and council room, while above are the windows of two laboratory floors; the top floor being lighted also from the roof.

The ground floor would be devoted to the administrative offices of the Institute, and below this the caretaker's quarters. An ample basement gives further accommoda-

It was originally estimated that the buildings and fittings would cost about £15,000, and an appeal made to fellows and associates of the Institute has resulted in the receipt of contributions and promises amounting, with dividends and interest, to over £11,600.

The Council have expressed their sense of gratitude to all who have enabled them to report this substantial progress, and record especially their indebtedness to several of the great city companies, as well as manufacturing companies and firms, whose names appear on the list of contributors, and who have thus shown their sympathy with the aims and objects of the Institute.

It is now estimated that £5,000 more will be required to complete the simplest possible scheme: The Council look to the generosity of all who are interested in chemical science, and who sympathise with scientific endeavour, to assist them in this undertaking; and they appeal especially to those who derive benefit from the services of chemists, and who realise the importance of the science of chemistry to the progress of industries.

PERSONAL AND OTHER NOTES.

MR. COURTHOPE, M.P., recently introduced a Bill into the House of Commons to prohibit the use of hop substitutes, and providing for the compulsory marking of imported hops. Evidence given before a Select Committee showed that the ingredients of these substances included quassia, gentian, camomile, and (in one instance) arsenic and antimony.

The executors of the late Sir J. Wernher, Bt., have completed the allocation of the £100,000 bequeathed to them to be devoted to charitable and educational purposes. Among the grants in this country are the following: £5,000 to the Institute of Mining and Metallurgy; £2,500 to the Imperial Service College; and £1,500 to the London School of Tropical Medicine.

At the instance of the Malt Extract Committee, appointed by the Council of the Society of Dyers and Colourists, three new processes for estimating the diastatic or liquefying properties of malt extracts were recently presented before the London Section of that Society by R. J. May, Dr. Herz, and W. P. Dreaper respectively. These have been provisionally examined by the Committee and have been published with a view to securing further criticism.

At the forthcoming meeting of the Society of Public Analysts on June 4th, at 8 p.m., the following papers will be read: "An Electro-Chemical Indicator for Oxydisers," by Eric K. Rideal and Ulick R. Evans; "The Estimation of Tannin in Tea," by Henry L. Smith; "The Detection and Estimation of Nickel by Means of α -Benzil-dioxime," by F. W. Atack; "The Analysis of Various East Indian Tanned Hides," by M. C. Lamb; "Note on the Sterilisation of Rag Flock Samples," by Lester Reed; and "A General Method for the Detection of Caramels," by P. F. Thompson.



tion for the caretaker, and provides cellars for storage purposes for the Institute.

The residence for the registrar under this full scheme would occupy a space at the western end of the site, and is designed so that it may be, at any time, conveniently utilised when necessary for the business purposes of the Institute.

It is hoped that the negotiations for acquiring the lease will soon be completed, that the building will be commenced in the next few months, and that it will be opened towards the end of 1914.

NOTES ON CHEMICAL ENGINEERING.

By J. W. HINCHLEY, A.R.S.M., Wh.Sc.

CHAPTER I. (*continued*).

SIZE-REDUCTION OF SOLID MATERIALS.

Stamp Mills.—In these machines, reduction is brought about mainly by crushing with blows upon the supported material. They are only used to a small extent in chemical factories, but in the allied mining and metallurgical industries have enormous application. The material to be crushed rests in a mortar, while blows are struck upon it by a pestle. The pestle or stamp may be lifted by cams and allowed to fall by gravity, or steam may be used, so that the stamp mill becomes a modification of the steam hammer. In many types, air cylinders and springs are used to modify the action of the stamp and to minimise the loss of energy due to unnecessary shocks. Since the

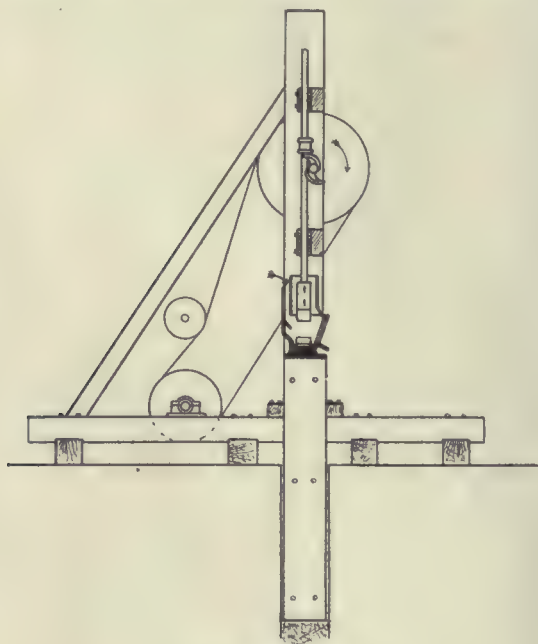


FIG. 21.—STAMP MILL.

principal wearing parts of such machines, viz., the die in the mortar and the shoe on the pestle or stamp, are cheaply and readily replaced when worn out, their capacity for reducing different materials of variable and great hardness balances their obviously inefficient principle of action. As a rule, the mortar is partially or wholly surrounded by inclined screens upon which the crushed material is projected by the blow, and through which a greater or less proportion of finely reduced material passes, while the residue falls back on to the die to receive the next impact. This separation of the fine material from the coarse is incomplete, but is improved by the addition of water, which, by splashing through the screens, carries material with it.

In the ordinary stamp mill used by the mining engineer (Fig. 21) the weight of the stamp varies from 700 to 1,200 lbs.; and the weight of the mortar from $2\frac{1}{2}$ to $3\frac{1}{2}$ tons. The screens are formed either of punched plate or woven wire. The most efficient screens are those which present the maximum area of opening with adequate strength. Punched plate screens are less efficient in action, on account of their smaller area of opening, and give less uniform product than wire woven screens, which, however, have a shorter life. Plate screens are usually punched with holes from .03 to .06 in. in diameter, the wire screens being 30 mesh, and giving more area of opening.

The height of drop of the stamps is determined by the condition of adequately covering the die with material to be crushed without causing undue wear on the die. The number of drops per minute is usually from 90 to 100, and the height of fall from 6 to 9 ins. The power required for such mills is usually $1\frac{1}{2}$ h.p. per stamp, and the output of pulp under good supervision 300 lbs. per h.p. per hour.

Small stamp mills with 200 to 250 lbs. stamps are sometimes used for crushing bones, phosphate rock, etc., but in this case the screens are very coarse. Still smaller stamp mills with globular stamps and cup-shaped mortars are used for crushing hard nuts, etc.

CHAPTER II.

SIFTING.

SIFTING consists in the use of surfaces with holes, called sieves or screens, for the separation of materials according to the sizes of their particles. It is an operation which is always avoided on grounds of economy, when possible. Useless wear and tear is a common accompaniment of screening processes, which are often badly arranged and thoughtlessly carried out.

In many industries the effect of crushing, moistening, or heating on the different constituents of the material often makes it possible for a simple screening process to separate them. A material which decrepitates may be separated from one which does not by roasting and sifting, or by simply sifting in a heated screen.

The simplest type of sifter is the fixed inclined screen. The screening surface in this case may consist of a series of bars bolted together with distance washers between each to form what is usually called a "grizzly." Such bar screens, 3 to 5 ft. wide and 6 to 12 ft. long, are generally inclined in the direction of the length of the bar at an angle of 45 degs. In screening materials where the breakage of the large fragments should be avoided (e.g., coal) the inclination should be made equal to or slightly less than the "angle of repose" of the material.

Fixed plate and woven wire screens are used in a similar way. Plate screens are punched with slots, whose length is in the direction of fall of the material; screens with circular holes are less efficient and give a product finer than the size of the holes. Woven wire screens (Fig. 22) formed of transverse stout wires and fine longitudinal wires forming slots, are very satisfactory for fixed screens. For the sifting of sand and gravel the inclination of such screens is about 60 degs., and the material is thrown at the screen by means of shovels.

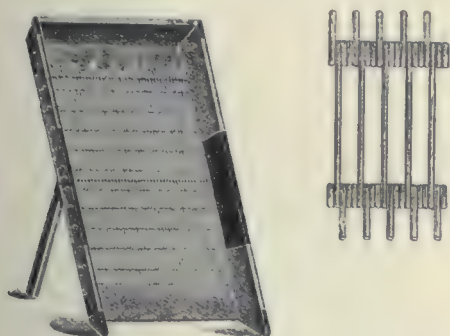


FIG. 22.—FIXED SCREEN.

Fixed screens for fine sifting are often arranged in a casing (Fig. 23), a current of air being drawn through the screening surface to increase the rate of sifting, while brushes on simple chain conveyors, moving above and below, clean the screening surface or prevent its choking.

Fixed screen sifters in which the material is moved across the sifting surface by mechanical means, such as brushes, paddles, etc., are very common in chemical work. In the simple type shown in Fig. 24, the sieve is trough shaped, and a rotating brush with bristles arranged in a spiral

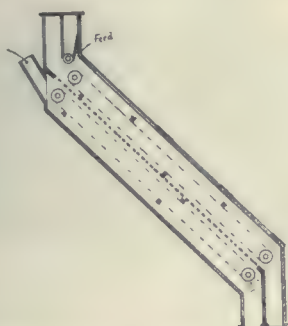


FIG. 23.—FIXED SCREEN IN CASING.

manner carries the material along the screening surface. The sifted material falls into the vessel upon which the sifter is placed, and the rejected portion is delivered into a small pocket at the extreme end. The brush is turned by hand, and a cover is provided to the hopper when in operation, to minimise the formation of clouds of dust. Power driven sifters of a similar type are often parts of other machines, and provide a preliminary treatment for the materials. A further modification is made by forming the sifting surface into a complete

cylinder (Fig. 25), and fixing it in an inclined position in a suitable casing. In this case the spiral brush is arranged rather to lift the material, so that it is well brushed against the screening surface. This machine is more suitable for materials which cake readily. A further modification consists in arranging a paddle wheel inside the screen which, on rotation, produces currents of air and throws the material against the screening surface. For coarse screening a horizontal screen with a central worm conveyor is often used, and, in some cases, lifting plates are fixed to the worm to turn the material over continuously.

In the most efficient sifting plant the screening

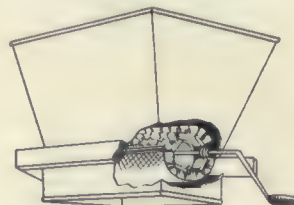


FIG. 24.—TROUGH SIFTER.

surface is made to move, vibrate, bump or shake, and additional apparatus is arranged to prevent the screen from choking. Flat screens are arranged for shaking, vibrating or bumping in a variety of ways. For small sifting operations the sieves are mounted in a drum with a charging space and cover above and a receiver below, and placed in a gyrating frame (Fig. 26). This frame is maintained in a horizontal position by means of suspension cords: In another type the frame strikes rubber buffers at each stroke.

A very efficient form consists of a series of sieves arranged in frames one above the other, and supported horizontally on vertical rods fitted at each end with ball and socket joints. The whole of the

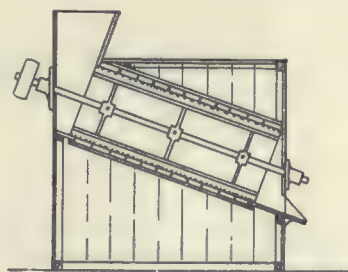


FIG. 25.—FIXED CYLINDRICAL SCREEN.

sieves are gyrated together, so that the material travels in circles, and is guided by pendent slats over the screening surface to the exit openings. A travelling brush is also arranged to clean the screens as the work goes on. A most convenient type of sifter, which may also serve as a conveyor, is shown in Fig. 27. In this case a number of sifting surfaces are arranged horizontally one above the other, each screen delivering its "tails" to its own spout, and are supported in a frame on flat springs inclined about 15 degs. to the vertical. The action is that of the ordinary vibrating conveyor; a crank or cam vibrates the nest of sieves at a rate of about 300

strokes per minute, the length of each stroke being capable of variations from 0 to 1 in. The rate of travel of the material along the screens may be altered by adjusting the length of stroke. At each stroke the material is thrown upward and forward, giving a very efficient sifting action.

Flat screens with gravity movement of the material are also vibrated vertically, or at an angle to their surfaces, which are in this case usually inclined 45 degs. In the "Newago" screen (Fig. 28)

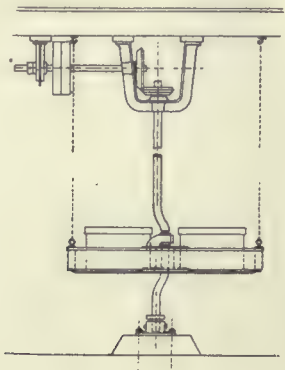


FIG. 26.—GYRATING FRAME.

of this type, small hammers are arranged to tap the frame of the screen and prevent choking.

Screening surfaces of a cylindrical, conical or pyramidal shape, which revolve on a central axis, form an important class of sifting machines. The trommel (Fig. 29) is used for coarse screening, and consists of a cylinder of perforated steel plate, mounted for rotation on an axle or on friction rollers. Cylindrical trommels are inclined at about 5 degs., so as to cause the material to slide rapidly through them. A common size of such machines is 5 ft. long and 2½ ft. diameter, the speed being

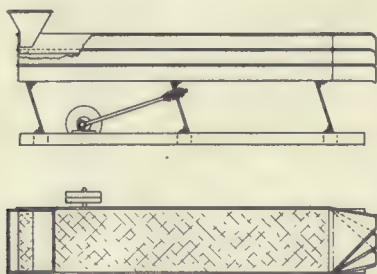


FIG. 27.—VIBRATING SIFTER.

20 revolutions per minute. Sometimes one trommel is arranged inside a second, so that two sifting operations take place at one time. Spiral screens, in which a continuous length of perforated plate is coiled in a spiral form, the coarser perforations being near the centre, also provide for more than one sifting operation. By the provision of stopping strips at points of the spiral, the discharge of the different grades of material at the ends of the screen is determined.

For fine sifting a series of circular supports

(Fig. 30), or a cylindrical framework, is provided, upon which the screening material is stretched. Such sifting "reels" are mounted in an inclined position in casings built in the factory. For materials which tend to clog, the circular form of reel is best, and an external rotating brush can be readily provided to clean the screening surface. For dry materials which do not clog hexagonal or

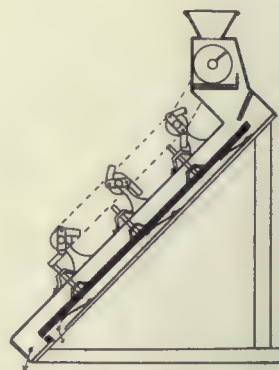


FIG. 28.—"NEWAGO" SCREEN.

octagonal frames may be used (Fig. 31). A worm conveyor is usually fitted in the base of the casing to discharge the sifted material.

In the sifting reel only the lower part of the sifting surface is in use, and its rate of working is consequently somewhat low. By the provision of a concentric paddle wheel turning with the reel, but not quite in contact with its surface, the material is lifted, and falls over the whole of the screening surface (Fig. 32).

A further step in rapid fine sifting consists in the provision of a paddle wheel with inclined blades or beaters (Fig. 33), which, rotating at a high speed,

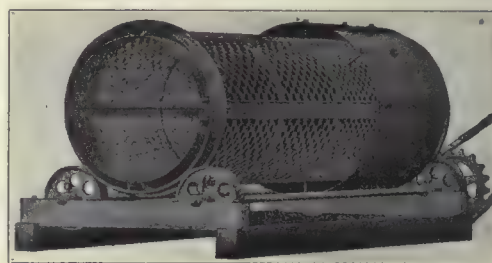


FIG. 29.—TROMMEL.

continually throws the material at the screening surface and produces a current of air, which increases the output enormously.

Such machines for the finest work are covered with silk stretched round the reel, laced in position, and held at the ends by means of spring clips.

The process of sifting does not lend itself to simple theoretical treatment, on account of the influence of factors whose magnitude varies and cannot be closely estimated.

In fixed screens, trommels and reels the angle of repose of the material is an important factor.

ANGLES OF REPOSE OF MATERIALS.

Anthracite coal (2 ins. to $\frac{1}{10}$ in.)	27 degs.
Wheat	28 "
Bituminous coal (2 ins. to $\frac{1}{10}$ in.)	35 "
Sand, crushed ore	34 "
Ashes, soft ore	40 "
Finely ground coal (98% through 100 mesh)	16 "



FIG. 30.—SKELTON REEL.

With the finest ground materials, if dry, the angle of repose becomes small, and a curved surface of repose is assumed.

Another important factor is the relation of the area of the openings in the sifting surface to the total

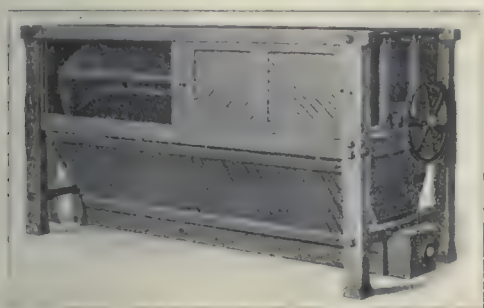


FIG. 31.—HEXAGONAL REEL.

surface, called the *opening factor*. The opening factor is always smaller for plate screens than for woven screens. If the holes in plate screens are punched $1\frac{1}{2}$ diameters apart, the opening factor, if the holes are arranged in equilateral triangles, is '403, if in squares, '319; at 2 diameters apart the

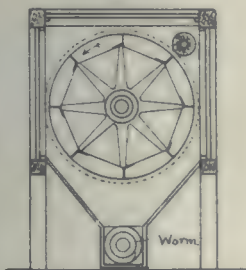


FIG. 32.—REEL WITH PADDLE ELEVATOR.

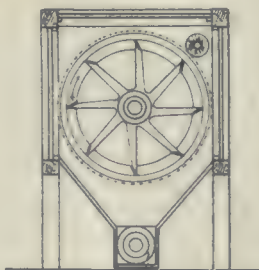


FIG. 33.—REEL WITH BEATERS.

figures become '226 and '196. In woven screens much higher factors are obtained, especially in coarse meshes. On the other hand, the life of the screening surface is shorter. The life of plate screens may be increased by increasing the thickness, since the holes may wear to a larger size before the screen gives way. A further advantage of plate screens is the fact that they do not choke so readily as woven screens.

(To be continued.)

ENGINEERING NOTES.

By R. J. DUNDERDALE, B.A. (CAMB.), A.M.I.C.E.

Mechanical Coke Quencher.

In "Stahl und Eisen," p. 1784 for 1912, there is an illustrated description of a mechanical coke quenching apparatus, as used at the Neumühl collieries.

It has been designed to handle large quantities of coke, and it is claimed that it can quench with about half the amount of water needed for the usual hand-quenching methods. It is claimed besides that when coke is made on at all a large scale, the coke-quenching labour bill is also very greatly reduced. These considerations would, of course, have to be set off against the initial cost and upkeep of the machine—but as it is of fairly simple construction, this should not be great.

Roughly, the design consists of a grid-box sliding up and down in a closed tank, which is adjusted so that the grid shall be just touching the water when the coke is shot on to it. The grid is then lowered and quenching takes place from the bottom—a very considerable advantage.

Acetylene Gas Plants.

In the *Times* engineering supplement of April 16th there is a short notice on house lighting plants using acetylene. The point of the notice is the means by which the acetylene can be safely put into the generating plant outside the confined space of the generating house without danger.

This in itself is doubtless a great advantage, but another very necessary step in this class of lighting (which naturally obtains most favour in outlying country districts) is to make the pipe system from the generator to and through the house as fool-proof as possible, for totally unskilled and technically ignorant people usually have to look after the whole concern from generator to burner.

Firms making these plants would probably be well advised to contract for the complete installing from *a* to *z*, and should also furnish the house with a clear plan of pipe lines and joints.

Paraffin as a Motor Car Fuel.

A good deal is heard from time to time about paraffin as a motor car fuel, but a perfectly satisfactory method of carburetting so that a car can run, start, stop and start again entirely on this liquid seems still required. The range of ignition is much smaller than with benzine, and the mixture of paraffin vapour and a little air has to be heated before entering the cylinder and meeting the main air supply. At this stage paraffin unfortunately tends to "crack," giving a very uneven ignition; and there is also a strong tendency to deposit carbon on cracking, both in the preheating arrangements and in the cylinder itself.

Coke Oven Gas as a Source of HNO₃.

An illustrated article on this subject begins on p. 1571 of "Stahl und Eisen" of 1912. The Deutsche Stickstoff-industrie is now working the process described on a considerable scale.

The method of working is as follows. An electric gas

compressor set supplies the gas at 60 lbs. per square inch and an electric air compressor the air at 90 lbs. per square inch to a bomb, consisting of a steel cylinder with spherical ends, where the mixture is ignited.

The air is heated after compression, and the addition of a small amount of oxygen is found greatly to increase the yield of HNO_3 .

The bomb is water jacketed.

It is claimed that satisfactory manures and similar nitrogenous products can be obtained from coke oven gases by this means.

NEW METHODS OF ANALYSIS.

A NEW TEST FOR THE DETECTION OF SACCHARINE SUBSTANCES IN URINE.

By ASSISTANT-SURGEON ARDESHIR K. TURNER, L.M.S.,
Government Laboratory, Byculla, Bombay.

THE writer, from the observation of a large number of quantitative estimations of the urea in urine made at the Government Laboratory, Bombay, with sodium hypobromite¹ in Gerrard's ureameter, was led to notice the following phenomena :—

(1) In the absence of sugar in the urine, the reaction between the hypobromite and the urine was not attended with the evolution of more heat than was sufficient to make the bottle, after shaking, just sensibly warm to the hand.

(2) In the presence of sugar this rise of temperature was noticeably more marked.

(3) After the reaction between the hypobromite and the urine was completed, the colour of the mixture was a deep yellow in the case of non-diabetic urines, but, in the presence of the sugar, its colour was distinctly paler, or even quite white.²

(4) The reaction in the case of diabetic urines was attended with the production of a cloudiness of the mixture, which on standing often deposited a white crystalline precipitate, but neither of these appearances were observed in the absence of sugar in the urine. The precipitate, on microscopical examination, also had a characteristic appearance, which will be described later.

With a view to further examination of these phenomena the following investigations were made :—

(a) The ureameter was modified, so that the rise of temperature, consequent upon the addition of 5 c.c. of urines to a known quantity (25 c.c.) of the hypobromite solution, could be directly estimated. For this purpose a thermometer, reading to $\frac{1}{2}^\circ \text{F.}$, was introduced through a third hole in the cork closing the mouth of the small bottle in which the reaction takes place in Gerrard's ureameter, and the urine was added by means of a burette, the nozzle of which projected through the cork into the bottle. When

performing an estimation with an apparatus so modified the temperature was observed to rise in every case for some time after the addition of the reagent until it reached a maximum, and then it began to fall slowly again. The maximum temperature attained was read off and the initial temperature of the hypobromite was subtracted from it to estimate the rise of temperature produced. A correction has to be made in the final reading, as the quantity of urine added from the burette displaces a quantity of the original air in the bottle. As this amounts to three divisions on the graduated scale this has to be subtracted every time an experiment is performed.

(b) Samples of urine were submitted to examination in the modified apparatus both alone and again after the addition of known percentages of glucose, the rise of temperature for each percentage of sugar being noted and compared with that of the unaltered urine, and the precipitate examined microscopically where any such precipitate was found.

(c) The effect of adding other substances, *e.g.*, urea, ammonium oxalate, oxalic acid, glycerine, cane-sugar, lactose, maltose, starch, acetone and diacetic acid, was noted both in regard to the rise in temperature and the formation of a precipitate and its microscopical appearance.

The results of these experiments are given in the appendices attached to this paper; they may be summarised as follows :—

(1) In the absence of the sugars or glycerine the rise of temperature varies between 7 to 24°F. , the rise being, roughly, dependent upon the amount of urea present, but not presenting any simple relation thereto.

(2) In the presence of the sugar or glycerine the rise is, in general, considerably greater, reaching even as much as 72°F. , which was noted in a urine containing 10% of added glucose, the same urine before fortification with glucose producing a rise of 21° only. A rise of 67°F. was noted in a urine containing 6% added glycerine, whereas the original showed a rise of 12° .

(3) The presence of small proportions of sugar cannot be definitely asserted from a consideration of the rise of temperature alone, owing to the fact that the quantity of urea present also affects the rise of temperature produced : thus a urine free from sugar, but containing 3% of urea, gave a rise of 24° , while another urine, containing 2.3% of urea and 0.25% of glucose, gave a rise of 15.5° only; but any considerable rise, say, above 24°F. , is very significant.

(4) Similar effects as to rise of temperature and the formation of the crystalline precipitate, to be described later, were produced with glucose, cane-sugar, lactose, maltose, glycerine, and starch when added to urine, but the addition of acetone or diacetic acid does not appear to influence the result to any considerable extent.

(5) The volume of nitrogen evolved from the urea present in urine is increased when pure glucose or glycerine (and to a less extent diacetic acid also) is added to it, probably owing to the more complete separation of the nitrogen effected at the higher temperature attained. The presence of glycerine or sugar then in a urine will result in the apparent increase in the percentage of urea present as estimated by this apparatus. On the other hand, the addition of acetone tends to diminish the volume of nitrogen evolved.

(6) In the absence of sugar this test will reveal the presence of glycerine in urine when present to the extent of 2% and upwards. Quantities smaller than this cannot be definitely asserted.

(7) An examination of the crystalline precipitate under

¹ The solution of hypobromite is made by adding 2.2 c.c. of bromine to 23 c.c. of a solution of soda made by mixing 100 gms. of NaHO with 250 c.c. of H_2O .

² The colour of the hypobromite is completely discharged when urine contains about 7% glucose.

the microscope (using a Leitz No. 7) gives an indication of the presence of saccharine substances which is exceedingly sensitive, the characteristic crystals being observed in as small an addition of glucose as 0.0017%, while the phenylhydrazin test will only detect 0.015% of the same substance (R. T. Williamson, *Medical Chronicle*, August, 1895). The same crystals are observed in urine containing from 0.25% to 1% added glycerine. No difference could be observed in the crystals obtained respectively from glucose, cane-sugar, maltose, lactose, starch and glycerine, the end product of the reaction being in all probability the same in each case. The crystals in the case of glycerine appear to take up the characteristic arrangement of a cluster of sheaves in the form of a cross, or a complete rosette. In the presence of glucose to an amount of 0.250% and upwards the crystals appear in the form of needles (about $\frac{1}{4}$ in. long) either separate or arranged in clusters in the form of double sheaves, single sheaves, brushes, stars, fans, etc. In smaller quantities no crystals are visible until the solution has stood for 12 hours or so, and then the form taken is that of opaque irregular masses (most of them round and triangular) with an internal striation commencing at the centre and radiating to the periphery, or even beyond the same at times.

The crystals are sparingly soluble or insoluble in absolute alcohol, but freely soluble in water, from which solvent they can be reprecipitated on the addition of 90% alcohol. The melting point of the crystals could not be ascertained, as they appear to remain unaltered at a temperature of 400° F.

In aqueous solution (or in powder) they do not reduce Fehling's solution. It is difficult to obtain them in a pure condition, free from NaHO, NaBr and NaOBr, and solutions of them usually give the reactions of these substances; but the reactions for oxalic acid are obtained in every case, and it seems probable that the crystals consist of an oxalate of soda, produced by oxidation of the sugar or glycerine by the hypobromite. On ignition they yield a small proportion of ash. Repeated recrystallisation from hot dilute alcohol may yield a purer product, which can be submitted to ultimate chemical analysis, but this operation has not yet been attempted.

It should be said that the writer has found the opaque striated masses described above in small amount in most cases of healthy urine similarly treated, but this may be due to the fact that minute traces of sugar are commonly found in the urine. This diminishes the value of the test slightly for minute traces of sugar, but the presence of definite sheaves appears to be pathognomonic, and these are seen in the presence of 0.250% of sugar.

If these results and conclusions are confirmed by other observers, a very useful addition will have been made to the tests for the presence of sugar and glycerine in the urine. The test appears to be an exceedingly delicate one, and it has the great advantage of not requiring any additional apparatus or chemicals, and, moreover, it can be performed at the same time as the routine method for the estimation of urea as at present carried out with practically no extra trouble.

The similar results obtained with other sugars will not, as a general rule, interfere with the value of the test. The increase in the apparent percentage of urea noticed as coincident upon the presence of added sugar is of importance. A correction should be made for this in drawing any conclusion as to the amount of nitrogenous waste occurring in a diabetic from the urea contents of the urine as estimated by the hypobromite method.

FINANCIAL NOTES.

THE report of the margarine concern, Van den Berghs, shows record results for the past year, as the following table will readily indicate:—

	1912.	1911.
Gross profit	£345,400	£246,300
Net profit	£260,400	£189,700
Dividend	25%	17½%
To reserve	£20,300	£13,300
To depreciation	£19,200	£17,600
Carry forward	£218,900	£200,100

The report for the past year of the San Lorenzo Nitrate Company shows a profit of £12,922, and the directors recommend a final dividend of 3s. per £3 share, making 5s. for the year.

After placing £100,000 to the reserve fund, the directors of the Nobel Dynamite Trust Company, Ltd., recommend a dividend of 8%, together with a bonus of 2%, for the year ended April 30th, carrying forward about £6,000.

Messrs. Bryant and May, Ltd., show net profits for the past year of £90,157, a decrease of £1,246 on the previous year's working. We append an interesting comparative table:—

	1912-13.	1911-12.
Net profit	£90,157	£101,403
Ordinary dividend	6%	6%
To insurance reserve	—	£10,000
Carry forward	£15,358	£16,400

The report of the Dalar Del Carmen Nitrate Co., Ltd., shows a net profit of £33,068. The directors recommend a final dividend of 20%, making a total distribution of 30% for the year ended December 31st, 1912.

The report of the Kuala Selangor Rubber concern shows a net profit of £42,976, as against £33,737 for the previous year's working. The following table is of interest:—

	1912.	1911.
Rubber (lb.)	303,740	168,692
Net average price	4s. 2.8d.	5s. 6.8d.
Net profit	£42,976	£33,737
Dividend	150%	107½%
Carry forward	£1,539	£3,563

The Anglo-Chilian Nitrate concern made about the same profit in 1912 as in 1911. We append a table of results:—

	1912.	1911.
Profit	£130,900	£131,700
Brought in	£84,200	£57,500
Total available	£215,100	£189,200
Dividend	15%	15%
Carry forward	£80,200	£84,200

Brunner, Mond and Company's total profits for the past year amount to £843,050, which includes £61,221 brought forward from the previous year. The dividend to be paid on the ordinary capital is 27½% per annum, which leaves a balance to be carried forward of £122,279.

After charging usual depreciation, fire insurance fund, etc., the Bleachers' Association show profits for the past year of £538,599. Six per cent. dividend has been paid during the year, leaving £145,302 to be carried forward, against £104,691 brought forward from the preceding year.

The Biochemical Society.—The next meeting will be held in the Institute of Physiology, University College, on June 11th, at 8.30 p.m.

REVIEWS OF BOOKS.

"DYEING AND CLEANING," a Practical Handbook. By **F. J. Farrell.** Third Edition. CHARLES GRIFFIN & CO., LTD., London, 1913. Pages 253 + viii, including Appendices and Index. Chapters VII., with 81 Illustrations. Price 5/- net.

THIS work has passed into the third edition, and has been written by a chemist who has a practical and extensive knowledge of the subject in hand. The work is divided into seven chapters, dealing with the technology of fibres, dry cleaning, wet cleaning, dyeing, dry dyeing, special methods, and finishing. The book is well illustrated with typical examples of plant used in actual practice, and the information given is of an essentially practical nature. It will be found to be of value to all those directly interested in the laundry trade, and generally to those who wish to obtain information of actual practice in this direction.

"THE LABORATORY BOOK OF MINERAL OIL TESTING." By **J. A. Hicks.** CHARLES GRIFFIN & CO., LTD., London, 1912. Second Edition. Pages 61 + x, including 32 Illustrations. Price 2/6 net.

In his introduction to the second edition of this work Sir Boverton Redwood remarks that this book "cannot fail to provide a most valuable practical guide to analytical chemists and others who are called upon to perform the class of work dealt with." This small work, which is well illustrated, deals with such questions as specific gravity, flashing-point, viscosity, and colour. It is up-to-date enough to contain an account of the new Redwood Viscometer for testing oil fuel for the Admiralty, in which the rate of flow is practically one tenth of that of the standard normal Redwood Viscometer.

In view of the recent published experiments conducted by Mr. Higgins at the National Physical Laboratory, this work will have an added interest at the present time. The final chapter deals with sundry apparatus which may be used in special cases in mineral oil testing. There can be no doubt as to the value of this work.

"MODERN INORGANIC CHEMISTRY." By **J. W. Mellor.** LONGMANS, GREEN & Co., London, 1912. Pages 871 + vii, including Index. Chapters XLIII., with 316 Illustrations. Price 7/6.

This text book deals in a satisfactory manner with the subject of inorganic chemistry, and contains a great deal of useful information in addition to the usual subject matter found in such text books. It is illustrated and contains chapters dealing with such subjects as crystallisation, combustion and flame, radioactivity, electrolysis, and electrical energy.

In an interesting preface the author deals with the teaching of chemistry from the teacher's point of view, and lays stress on the statement made by

Paracelsus that "the power to recognise and to follow truth cannot be conferred by academical degrees." Also that "an appreciation of method and not a knowledge of facts," should be aimed at. There can be no doubt but that this valuable volume will serve a very definite purpose, and be equally useful to the student and teacher.

"METHODS IN CHEMICAL ANALYSIS." By **F. A. Gooch.** CHAPMAN & HALL, LTD., London, 1912. Pages 536 + xii, including Indexes. Chapters XII., with 29 Illustrations. Price 17/- net.

This volume is apparently being used in the Yale University laboratories, and contains useful information as to the general methods of chemical analysis. The general scheme includes the estimation of beryllium, boron, lanthanum, cerium, thallium, vanadium, and other metals. It is a useful volume for the laboratory bookshelf, and contains information which is not generally met with in the more general text books on the subject.

"A HISTORY OF CHEMISTRY FROM THE EARLIEST TIMES TILL THE PRESENT DAY." By the late **James Campbell Brown.** J. & A. CHURCHILL, London, 1913. Pages 543 + xxv, including Index. Chapters L., including 106 Illustrations and Frontispiece. Price 10/6 net.

This work is based upon a series of lectures which were delivered at the Liverpool University by the late Campbell Brown, and is the result of a close study of many rare treatises on the subject which are not generally available. It is admirably illustrated by reproductions of old prints, etc. The present work has been compiled from notes, etc., by H. H. Brown, the late Campbell Brown's cousin. This has been successfully accomplished, with the result that the work is a text book which can be recommended to students who wish to have a general knowledge of the historical side of their subject. The work is divided into two sections, which deal respectively with ancient and modern history.

The first section is particularly interesting, and contains much information on the work of early writers, including illustrations of Greek apparatus from the original MS.

It is impossible to follow in detail the account given of the work of the Greek, Roman and Oriental workers, or that of the alchemists of the twelfth to the fourteenth centuries. The modern section starts with the work of the iatro-chemists and that of Basil Valentine, and then deals with the Phlogistonists and the Anti-Phlogistonists. The quantitative period is discussed at length, also the use of electro-chemistry. The last chapters deal with the history of chemical affinity, physiological chemistry, the carbon compounds and such like subjects.

BOOKS RECEIVED.

"The Examination of Waters and Water Supplies," by John C. Thresh. Second Edition. J. & A. Churchill, London, 1913. Pages 644 + xx, including Index and Appendix. Chapters XX., with 53 Illustrations. Price 18/- net.

"Liquid Air Oxygen Nitrogen," by Georges Claude. Translated by Henry E. P. Cottrell. J. & A. Churchill, London, 1913. Pages 418 + xxv. Chapters XIX., with 151 Illustrations. Price 18/- net.

"Evans' Analytical Notes for 1912." March, 1913. Messrs. Evans Sons, Lescher & Webb, Ltd., London. Pages 100.

"Sand Available for Filling Mine Workings in the Northern Anthracite Basin of Pennsylvania," by H. H. Darton. Bureau of Mines, Washington, U.S.A., 1913. Pages 33, with 5 Figures and 8 Plates. Bulletin 45.

"The Cementing Process of Excluding Water from Oil Wells as Practised in California," by Ralph Arnold and V. R. Garfias. Technical Paper 32, Bureau of Mines, Washington, U.S.A., 1913. Pages 12, with 1 Figure.

"Accidents from Mine Cars and Locomotives," by L. M. Jones. Bureau of Mines, Washington, U.S.A., 1912. Pages 16.

"Second Annual Report of the Director of the Bureau of Mines to the Secretary of the Interior, for the Fiscal Year ended June 30th, 1912." Bureau of Mines, Washington, U.S.A., 1913. Pages 88.

CORRESPONDENCE.

Bordeaux Mixture.

SIR,—Mr. H. J. Colbourn's letter in the May number of THE CHEMICAL WORLD raises an interesting point in connection with the fungicidal action of Bordeaux Mixtures. Discussing the view taken by Professor Barker and myself, that it is impossible to consider the action of atmospheric CO₂ as the most important means by which the fungicidal properties of Bordeaux Mixtures are brought into play, but that this must rather be ascribed to a direct solvent action on the part of the fungus, Mr. Colbourn questions whether we may not have overlooked the CO₂ which is given off by plants in the process of respiration.

As the result of experiments referred to in an article in THE CHEMICAL WORLD for November last (for details, see *J. Agric. Sci.*, 1911, 4, 69, 76), it is concluded that only in presence of a large excess of CO₂ is there an appreciable amount of copper brought into solution from a film of Bordeaux Mixture, and that only so long as such an excess is maintained does any copper so dissolved remain in solution. In considering what happens under natural conditions out of doors, it is, therefore, simply a question of the amount of CO₂ present at any time in the immediate neighbourhood of the sprayed leaves. Unfortunately we do not at present know the precise state of affairs in a film of dew or rain on the surface of a leaf; but that there should ever be the necessary excess of CO₂—even on the stillest nights—to dissolve enough copper to exert a fungicidal action seems most unlikely. Some experiments bearing on this point are, however, now in progress.

I am, Sir, etc.,

C. T. GIMMINGHAM.

May 13th, 1913.

COMMERCIAL
AND GENERAL NOTES.

The German Ammonia Industry.

Some interesting details of the German ammonia industry are contained in the annual report issued by the Ammonia Sales Syndicate. According to this report, the turnover during last year was quite satisfactory, although the supply was greater than the demand, especially during the last six months. In consequence of constant rains the foreign buyers put off ordering the material required for the autumn season, and the resulting accumulation of stocks depressed the market tendency, in spite of an advance in nitrate prices. The sales of the Syndicate during the year under review reached 309,947 tons, compared with 283,011 tons during the preceding twelve months. Of the former quantity 67,148 tons (against 74,368 tons) were sold to foreign countries. Germany consumed about 425,000 tons, or an increase of 55,000 tons against 1911. Although the German output of ammonium sulphate was estimated at 465,000 tons, imports amounted to 23,098 tons (against 24,463 tons in 1911), of which 1,884 tons were of British origin, and 23,098 tons (against 24,463 tons) came from Austria-Hungary.

Germany's lead in the production is due to her increasing use of by-product coke-ovens and producer gas plants. An interesting comparison of the production of sulphate of ammonia in all countries is made by the *Journal of Industrial and Engineering Chemistry*. According to that journal the world's output during 1912 was as follows:—

	Tons.
Germany	465,000
United Kingdom	379,000
United States	155,000
France	68,500
Belgium	49,500
Other countries	170,000
	1,287,000

Paper from Asparagus, Bean-straw and Pea-straw.

The possibility of making paper from asparagus has recently formed the subject of discussion in the Continental press. Dr. Otto Reinke, of Braunschweig, is the inventor of a new process for the utilisation of asparagus grass for paper-making, the practical value of which has, however, been questioned by the German technical press. Thus, the *Papier-Zeitung*, of Berlin, the leading journal of the paper-making industry of Germany, recently expressed the opinion that Dr. Reinke's efforts would not prove an economical success. In spite of this criticism Dr. Reinke has continued his research work in the same direction, and was lately able to announce in the *Braunschweigische Landeszeitung* that he has worked out a new chemical process for utilising the straw of peas and beans, which is at present of such little value as to be considered waste. Both kinds of straw furnish a high percentage of cellulose suitable for many purposes. The utilisation of waste straw is of considerable importance to agriculturists cultivating peas and beans for canning purposes, as it promises them a good return for their efforts, even if bad crops would otherwise leave no profit.

Crude Carbolic as a Larvicide.

Crude carbolic acid has been used with complete success as a larvicide on ponds in British Guiana. According to the "Annals of Tropical Medicine," experiments made with the acid proved its usefulness by killing the larvæ in about an hour, while it took about 24 hours to destroy the pupæ. The observers were inclined to the belief that, in the case of a temporary small collection of water, if crude carbolic acid is applied, it does not evaporate to any large extent, but concentrates as the puddle dries up, and, further, that, having dried up, the ground is sufficiently impregnated with the carbolic acid to render water deposited later by a shower of rain fatal to larvæ. A dilution of 1 in 20,000 is efficient as regards all larvæ inside two hours, but in the case of pupæ a much longer time is required. The crude carbolic containing all its impurities, such as cresol, rosolic acid, oily and tarry substances, is much more effective than the purified, more highly soluble product, possibly owing to its sticky nature making it more adherent to the larvæ and pupæ.

Potash from Felspar in Sweden.

The attempts to produce potash from felspar, which are being made in Sweden, have aroused considerable interest among Continental potash producers. The German Syndicate, which is chiefly concerned in any attempt of this kind, considers the Swedish project futile. The reason for doubting its success was stated in a recent discussion of the matter. One prominent member of the Syndicate said: "We have been aware for some time that a potash extraction process is being tried. Sweden is one of the Syndicate's best customers, taking yearly some 7,000,000 marks' worth, so it is not surprising that attempts should be made to meet the demand from local sources. But between experiments in a public laboratory and the successful commercial application of the process is a wide gulf. The whole question hangs upon the cost of production, and if it is proposed to prepare potash by such a process as that described, the price will be prohibitive. Large quantities of rocks containing potash in insoluble or sparingly soluble form exist in Germany, but it has not hitherto been found profitable to purify and free the salts they contain, and the same is anticipated of the Swedish article."

Economy in Synthetic Dyestuffs.

In a review of the textile industry of Europe, which has been prepared by the Elberfeld Chamber of Commerce, the dyeing industry as it relates to the textile trades in different parts of Europe is discussed. In connection with this report the following comments are made regarding the economy of synthetic dyestuffs:—

"The success of Professor Green's work at Leeds in the determination of the constitution of aniline black is not only of scientific interest, but is of great importance to the dyeing trade. The *Manchester Guardian* thinks it should make it possible, in the first place, to economise in aniline. In the second place, the determination of the constitution of aniline black will probably lead to the discovery of analogous colours, with different bases, produced, like aniline black, on the fibre. That has almost always been the result in the history of synthetic dyestuffs of such work as that of Professor Green.

"It was in the course of these investigations that Professor Green patented his method of dispensing with potassium ferrocyanide and sodium chlorate—the agents

which are used to oxidise aniline on the fibre—and so to produce aniline black. The method is to use the oxygen of the air, by means of a catalyst (cuprous chloride). It has been utilised for the last year or two by a few of the great dyeing firms, and has been found to be of great advantage."

Raisin Seed Utilisation.

Another of the interesting and useful reports of the Bureau of Plant Industry (of the Department of Agriculture of the U.S.A.) has recently appeared. It is compiled by the chemical biologist of the Bureau, and deals with the utilisation of raisin seed. The investigator of this subject shows that four important commodities are obtainable from the utilisation of waste raisin seeds, including an oil suitable for use as a paint and varnish oil, and also in soap-making, and that an extract of tannin results from a proper treatment of these seeds. From the syrup, it is said, that a large quantity of fermentable sugar is obtainable; the commercial production of alcohol from this by-product is possible. According to experiments made with this syrup, it is asserted that a total of 23.4% of absolute alcohol can be obtained by fermentation.

After the extraction of oil and tannin, there is a residue left, which has been termed a meal, and which might possibly be used as stock feed. In regard to the available quantity of oil obtainable from raisin seeds it is shown that from 90,000 to 120,000 gallons are available annually. The tannin found in these seeds represented 28 to 38%.

Flax Straw Utilisation in Canada.

A new company has been incorporated in Manitoba trading under the firm of Flax Decorticating Co., Ltd. The object is to separate and extract the fibre from flax straw in order to utilise it as high-class material for paper pulp. The company's ultimate object will, however, be to refine the extracted fibre and dispose of it for coarse textile purposes. There are large quantities of waste flax straw, now burned throughout the north-west territory, which might be made to yield a good profit if utilised economically.

Milk Powder in Germany.

Interesting experiments with milk preserved in the shape of a dry powder have recently been carried out at several German Government experimental stations. Quite a number of preparations of this kind have been put on the market in Germany, and it appeared desirable to obtain some data as to their nutritive value, their quality for keeping, etc. In the province of East Prussia there are nine firms making milk powder of different class. The process of manufacture is said to be very simple, but expensive, the owners of the patents receiving large royalties, and the necessary machinery not being sold outright, but let on lease. Milk powder prepared from skim milk has been found to last much longer than powder made from milk containing full cream. This latter preparation is apt to get a slightly rancid taste after a short time. Both kinds are fairly, though not completely, soluble in water at a temperature of 50° to 60° C. For the preparation of milk puddings, chocolate, sweets, etc., for military and scientific expeditions, they have proved very useful. They must not, however, be used for infant feeding, on account of their incomplete solubility. The use of milk powder as an addition to bread, is, however, advocated by German scientists, as this would considerably increase the nutritive value of the "staff of life."

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.

1598/12. L. COLLARDON. **Plastic Compound.**

A product consisting of hydrocellulose and condensation products obtained from phenol or cresol and formaldehyde is manufactured by incorporating such condensate in the pasty condition into cellulose xanthate by mechanical means without the addition of solvents and finally removing the alkali and sulphur products by steaming and washing.

3873/12. F. E. MATTHEWS, E. H. STRANGE, and H. J. W. BLISS. **Butadiene.**

Butadiene, or homologues thereof, is manufactured by treating a primary or a secondary glycol or a mixture of both primary and secondary glycols, or a primary-secondary glycol so as to effect the removal of two molecular proportions of water.

5024/12. N. TESTRUP and T. RIGBY. **Gas Producers.**

Fuel for gas producers consists of an admixture of press cake material of wet carbonised peat and briquettes made thereof or such briquettes after coking or charring.

5328/12. P. SCHIDROWITZ. **Rubber.**

Low grade rubber gums are dried in vacuo at a low temperature, preferably below that of boiling water.

5601/12. P. R. BOULTON. **Automatic and Continuous Analysis and Indication of Gases.**

5806/12. N. V. HYBINETTE. **Copper.**

Copper is extracted from sulphide ores by roasting in the presence of a smaller amount of sodium sulphate, leaching with weak acid, and electrolysing the solution thus obtained.

6971/12. C. WOOD. **Coating Iron Sheets with Aluminium.**

7272/12. J. A. LIEBERT. **Yeast.**

7422/12. S. EVERETT. **Distillation, Fractionation or Refining of Liquids.**

7687/12. L. LEDERER. **Cellulose Esters.**

Aqueous gelatinous solutions of acetylated cellulose are manufactured by causing acetic anhydride and sulphuric acid to act on cellulose or its closely related conversion products. The product of the reaction is subjected to the action of water for more than a day.

7712/12. A. F. MATLACK. **Gas Producers.**

7768/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & Co. **Isatin Compounds.**

New isatin compounds are produced by treating isatin, 5-chloro- or 5-bromoisatin with chlorine or chlorinating agents with or without the use of chlorine carriers in an aqueous suspension.

7869/12. WAHL-HENIUS INSTITUTE OF FERMENTOLOGY. **Fermented Malt Beverages.**

8426/12. G. FUSINA. **Treatment of Sulphurous Ores.**

8510/12. BADISCHE ANILIN and SODA FABRIK. **Indigoid Colouring Matters.**

Bisulphite compounds of unsymmetrical indigoid colouring matters are manufactured by treating such colouring matters with an acid sulphite.

8546/12. S. POPE. **White Pigments.**

8871/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & Co. **Manufacture and Production of Beta-gamma-dimethyl-erythrene.**

9314/12. P. G. TUQUET. **Industrially Sterilising Water by Means of Electric Mercury Lamps Generating Ultra-violet and Similar Rays.**

9509/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & Co. **Dyes.**

New dyes of the anthracene series are produced by treating anthraquinonylethers of anthraquinone mono- or di-mercaptans or their derivatives with condensing agents.

9981/12. C. H. FISCHER. **Tungsten.**

Pure crystalline ductile tungsten is produced by reducing pure anhydrous tungstic acid by means of a hot current of hydrogen in the presence of a volatile drying agent, such as phosphorous pentoxide.

10793/12. G. WEYMAN and T. HARDIE. **Gas Purification.**

12615/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & Co. **Manufacture and Production of Indophenol Condensation Products and their Leuco-derivatives.**

12617/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & Co. **Vat Dyestuffs.**

New vat dyestuffs of the anthraquinone series are produced by treating with aluminium chloride the condensation products obtained from one molecule of a di- or polyhalogenbenzene or of its substitution products, and at least two molecules of an alpha-aminoanthraquinone or of its acylamino substitution products.

14607/12. E. E. NAEF. **Cyanogen Compounds from Calcium Cyanamide.**

14755/12. B. C. BESLEY. **Extraction of Tin from Base Bullion as Oxide or Metal.**

14943/12. BADISCHE ANILIN AND SODA FABRIK. **Indole.**

Indole is manufactured by treating indoxyl or indoxyl-carboxylic acid with caustic alkali or a mixture of caustic alkali and caustic alkaline earth in the presence of water at a temperature of from about 150° C. upwards.

15146/12. BADISCHE ANILIN AND SODA FABRIK. **Azo Colouring Matters.**

15227/12. H. H. BISHOP. **Manufacture of Hydrofluoric Acid.**

16413/12. B. BENEDIX. **Saponaceous Product.**

A fatty saponaceous product is manufactured from vaseline oil by intimately mixing the vaseline oil in the presence of water with hydrogen peroxide or sodium peroxide diluted with alkalies or alkaline salts.

16698/12. KALBE & Co. AKTIENGESellschaft. **Acetyl Compounds of the Amido-azo-benzene Series.**

17038/12. F. I. DU PONT. **Obtaining Oxides of Nitrogen from Atmospheric Air.**

17603/12. C. H. FISCHER. **Tungstic Acid.**

According to this invention, a large excess of fused alkali is mixed with lime and the powdered ore (scheelite) is added in small doses so as to form a smelt. The mixture

is then well stirred and allowed to cool. The cooled mass is lixiviated in water to dissolve out the potassium tungstate, filtered, and the filtrate treated to separate out the tungstic acid.

18148/12. THE FIRM OF POETTER, G. M.B. H. **Open-Hearth Furnaces.**

In a regenerative open-hearth furnace, the waste gases are caused to pass successively or in series through a recuperator and a regenerator, whilst the fuel gas and the combustion air are caused to pass in parallel through the recuperator and the regenerator, the recuperator being preferably employed for heating the air and the regenerator for heating the fuel gas.

18966/12. A. SKITA, Karlsruhe. **Hydrogenising Substances.**
18 September, 1911.

A process for hydrogenising substances having double or treble linking, consists in causing hydrogen to act on the substance or a solution or a suspension thereof, in the presence of a small proportion of a compound of a metal of the platinum group in a dissolved state. (1 claim.)

19572/12. T. L. WILLSON. **Superphosphates.**

The conversion and drying of monocalcium phosphate (with or without an excess of phosphoric acid) which has been prepared from natural phosphate rock by the addition of phosphoric acid, is effected by ammonia gas.

19764/12. BADISCHE ANILIN AND SODA FABRIK. **Manufacture of Chlorine Derivates of the Amyl Series.**

22029/12. J. H. THWAITES AND THE ZENO CO., LTD.
Treatment of Copper Liquors.

22201/12. FARBFABRIKEN, VORMALS FRIEDRICH BAYER & CO. **Printing with Vat Dyestuffs of the Anthraquinone Series.**

22655/12. A. FRANCE and P. HABETS. **Apparatus for Washing Coal and Other Minerals.**

25493/12. FARBERWERKE, VORMALS MEISTER LUCIUS AND BRUNING. **New Derivatives of Animo-oxyary Larsinic Acids.**

26497/12. E. W. JUNGNER. **Alkali.**

A process producing alkali from feldspars or mica consists in mixing said minerals in a pulverised state with lime, heating the mixture to such a temperature that the alkalies are driven out by the lime and volatilised, and condensing and collecting the alkalies.

27228/12. CHEMISCHE FABRIK AUF ACTIEN (VORMALS E. SCHERING) and A. LOOSE. **Cellulose.**

In a process of acetylating cellulose and its products of transformation, a sulphate of hydrazine or of hydroxylamine or mixtures thereof is employed.

28970/12. E. W. JUNGNER. **Manufacture of Alkali and Hydraulic Cement.**

613/13. O. RÖHM. **Rubber Substitute.**

A rubber substitute suitable for industrial application is manufactured by subjecting to vulcanisation a solid acrylic acid ester obtained by polymerisation.

940/13. FARBFABRIKEN, VORMALS FRIEDRICH BAYER & CO. **Manufacture of 1·3-butyleneglycol.**

A process for the production of 1·3-butyleneglycol consists in reducing aldol by electrolysis.

4246/13. G. DE BECHI. **Industrial Separation of Lead and Zinc contained in the state of Sulphides in Ores.**

SHARE LIST.

Name of Company.	May 24th.		April 25th.	
Alby United Carbide	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Ditto. Pref.	1	1 $\frac{1}{2}$	1	1 $\frac{1}{2}$
Associated Portland Cement. (10)	7 $\frac{1}{2}$	7 $\frac{1}{2}$	7 $\frac{1}{2}$	8
Ditto. Pref. (10)	8 $\frac{1}{2}$	8 $\frac{1}{2}$	8 $\frac{1}{2}$	9 $\frac{1}{2}$
Babcock-Wilcox. Ord.	2 $\frac{1}{2}$	3 $\frac{1}{2}$	3 $\frac{1}{2}$	3 $\frac{1}{2}$
Ditto. Pref.	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Bell's United Asbestos	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Bleachers' Association. Ord. ..	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Ditto. Pref.	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Borax Consolidated. Pfd. (5) ..	5 $\frac{1}{2}$	5 $\frac{1}{2}$	5 $\frac{1}{2}$	5 $\frac{1}{2}$
Ditto. Defd.	1 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$
Ditto. Pref. (10)	11	11 $\frac{1}{2}$	11 $\frac{1}{2}$	12
Bradford Dyers	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Ditto. Pref.	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
British Oil and Cake. Ord. ..	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Brunner Mond. Ord.	4 $\frac{1}{2}$	5 $\frac{1}{2}$	4 $\frac{1}{2}$	4 $\frac{1}{2}$
Ditto. 7% Pref. (10)	15 $\frac{1}{2}$	15 $\frac{1}{2}$	15	15 $\frac{1}{2}$
Bryant and May. Pref.	2 $\frac{1}{2}$	2 $\frac{1}{2}$ xd.	2 $\frac{1}{2}$	2 $\frac{1}{2}$
Calico Printers	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Ditto. Pref.	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Castner Kellner	3 $\frac{1}{2}$	3 $\frac{1}{2}$ xd.	3 $\frac{1}{2}$	3 $\frac{1}{2}$
Commercial Salt. (2/-)	5/-	5/6	3/6	4/-
Crossley & Sons. (2)	1 $\frac{1}{2}$	2	1 $\frac{1}{2}$	2
Ditto. 5% Pref.	4 $\frac{1}{2}$	4 $\frac{1}{2}$	4 $\frac{1}{2}$	4 $\frac{1}{2}$
Eastman Kodak. (\$100)	690	720	700	730
Eley Brothers	1 $\frac{1}{2}$	2 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Fraser and Chalmers. (£3)	1 $\frac{1}{2}$	2 $\frac{1}{2}$	1 $\frac{1}{2}$	2 $\frac{1}{2}$
Gas Light and Coke. (S.)	102	104	101 $\frac{1}{2}$	103 $\frac{1}{2}$
Ditto. 4% Pref. (S)	94	97	95	98
Greenwich Lino. (1)	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Harrison and Crossfeld. Pref. ..	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Imperial Continental. (S)	167	170xd.	171	176
Ditto. 3 $\frac{1}{2}$ % Debenture (S) ..	85	87	85	87
India Rubber Co. (10)	11	12	10 $\frac{1}{2}$	11 $\frac{1}{2}$
International Salt	9/-	9/6	9/6	10/-
Ditto. Pref. (5/6 pd.)	2 $\frac{1}{2}$	2 $\frac{1}{2}$ pm.	3	3 $\frac{1}{2}$ pm.
Lever Brothers. 1st Pref. (10) ..	11	11 $\frac{1}{2}$	10 $\frac{1}{2}$	11 $\frac{1}{2}$
Lister & Co. Ord.	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Mappin & Webb. Ord.	1 $\frac{1}{2}$	1 $\frac{1}{2}$ xd.	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Neuch'tel' Asphalt. (10/-)	9 $\frac{1}{2}$	10 $\frac{1}{2}$	9 $\frac{1}{2}$	9 $\frac{1}{2}$
Nobel Dynamite. (10)	17 $\frac{1}{2}$	18 $\frac{1}{2}$	17 $\frac{1}{2}$	18 $\frac{1}{2}$
Ditto. Bearer (10)	18	18 $\frac{1}{2}$	18	18 $\frac{1}{2}$
Ditto. 5% Pref. (10)	11	12	10 $\frac{1}{2}$	11 $\frac{1}{2}$
Pears, A. and F. Ord.	11 $\frac{1}{2}$	13 $\frac{1}{2}$	13 $\frac{1}{2}$	14 $\frac{1}{2}$
Ditto. 6% Pref. (10)	11 $\frac{1}{2}$	12 $\frac{1}{2}$	12	12 $\frac{1}{2}$
Price's Candle. (16)	35	37	35	37
Rosario. (5)	9 $\frac{1}{2}$	9 $\frac{1}{2}$	9 $\frac{1}{2}$	9 $\frac{1}{2}$
Salt Union. (4)	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
South Metropolitan 4% Standard (S)	110	112	111	113
Ditto. 3% Debenture (S)	73	75	73	75
United Alkali. (10)	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Ditto. Pref. (10)	9 $\frac{1}{2}$	10	9 $\frac{1}{2}$	10 $\frac{1}{2}$
Val de Travers	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$

Market Report.—The imports to Japan of fertilisers of various descriptions during last year amounted in value to 52,320,590 yen. These figures show an increase of 51,469,577 yen as compared with the returns for 1911, and an increase of 14,370,000 yen as against 1910. The appended table shows the principal fertilizers imported last year:—

	Quantity. Kin.	Value. Yen.
Bean-oil bran	863,426,700	23,521,758
Phosphorite	477,541,200	7,458,198
Sulphate of ammonia	140,998,602	12,164,092
Cotton-seed oil bran	34,109,900	1,033,502
Other vegetable oil		
bran	108,761,300	2,719,573
Animal bone	47,605,417	1,358,305

Chamber of Commerce Journal.



THE CHEMICAL WORLD

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CHEMISTRY AND CHEMICAL ENGINEERING

EDITED BY W. P. DREAPER, F.I.C.

"Science moves, but slowly, slowly creeping on from point to point."—TENNYSON.

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JULY, 1913.

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Time and Cost.

THE publication in full of Mr. C. A. Hill's recent lecture on "The Function and Scope of the Chemist in a Pharmaceutical Works" is undoubtedly of great interest to the young student, for it indicates in a very emphatic way the multifarious requirements and the conditions under which a chemist may be required to work. Particularly interesting are the remarks concerning the initial difficulties with which the young chemist will inevitably meet with in actual practice.

In such a works, where thousands of different products are being manufactured, quite different in character, some in tons, and some in ounces, some constantly being manufactured, and some only perhaps once a year, the conditions of working are not easy, or well defined. They obviously represent conditions which entail a severe training for the young chemist, and which are described as follows:—

"Though he will be able to consult with his 'chief' and with colleagues from other departments, yet he must remember that he is not in a teaching establishment and that his seniors, having their own work to do, cannot attend on him the day long with advice, hints, and help. Apparatus, materials, and information will not walk to his right hand of their own accord, while he must make up his mind to ferret out for himself—in face it may even be of some little opposition—information as to his raw materials, their cost, and whether he is having supplied to him the particular kind of quality best suited to his purpose. He must be prepared to find out for himself exactly what is wanted and what it is wanted for, and even to cope with unsympathetic treatment when seeking information in departments other than his own. In fact, considerable initiative is necessary in order that he may be in a position to utilise and apply his chemical knowledge."

This is well put, and graphically descriptive of actual conditions as they exist.

When a process has to be worked under commercial conditions, Mr. Hill rightly points out that the three important items of "cost" are *time, labour, and yield*; the last-mentioned factor being of greatest importance.

The student who enters a factory or works has naturally little idea of what is required of him, or how he may apply his chemical knowledge. Under modern conditions he will at once observe the existence of a fairly sharp distinction between the manufacturing and analytical sides; and again, between these and the department of investigation and research. Also that all these are in some way intimately connected, and linked up with the commercial side of the business. In the past it was not an uncommon thing for the technical staff to be composed of one, who was called "The Chemist." He was expected to manufacture, analyse, investigate, and advise upon technical matters, and even in some cases act as consulting engineer. To-day these conditions have changed, and the need of properly trained chemists in all departments is recognised, while modern business conditions demand increasing specialisation. It is interesting to note that Mr. Hill considers that in all works, of whatever size, the supervision of the technical problems is, or should be, vested in one chief chemist. We are inclined to agree with this, with the necessary reservation that the chemist must be an all-round man whose training has been based on broad lines.

In the particular work Mr. Hill is dealing with, the preparation of chemicals which are free from all harmful impurities is no easy matter, especially when those existing in the raw materials have to be considered in the finished product. As an example, he points out that in the manufacture of magnesia, one part per million of lead in the raw materials may become thirteen parts in the resulting magnesium oxide. The very objectionable nature of the presence of certain toxic substances, such as lead or copper, which may creep in from the chemical plant employed, must be very rigidly excluded from the final product on physiological grounds.

When the student passes from the restrained air of the college laboratory to the practical and moving life of the works, the change is an immense one. His first experience at, say, filtration of more or less difficult liquids, will open his eyes to the difficulties of commercial work, especially when the essential factors of time and expense have to be considered.

We would particularly direct the notice of

students who are leaving college to this publication, for it bears the stamp of actual experience, and presents a picture of working conditions which cannot fail to impress itself upon the mind of those who have not yet come into direct contact with them.

* * * *

While dealing with this matter, it is interesting to remember that Mr. F. H. Carr (*CHEMICAL WORLD*, 1912, I, 272) has suggested that the conditions which actually exist in the works might be brought directly before the student during the college period by the provision of a model working factory, dealing with the production of varied chemical products which might be distributed in certain specified directions. Thus organic and inorganic chemicals would be manufactured on a moderate scale for use in certain educational establishments or research laboratories, under the strictest principles of management, economy, costing, analysis, and discipline. It is suggested that in this way the students might get a preliminary insight into the efficient control and administration of a modern factory. Also that they should be taught to work out costs, etc. The problems set should be of such an order that they would test and develop the student's resourcefulness, with the object of obtaining the maximum of product with the minimum of unprofitable labour, special attention being devoted to the speed of their analytical work.

If it is advisable for students to gain insight into such operations during their college course, Mr. Carr has probably suggested the line of least resistance. However, so many factors are involved in the success of such a scheme, that only actual trial could establish its value, and then only when working under conditions which are not often met with in our colleges. The success, however, which has resulted in some cases, as, for instance, at the Leathersellers' Technical College, Bermondsey, indicates that it is not impossible that such a scheme might meet with ultimate success.

Arsenical Poisoning.

At the time when the question of lead poisoning in connection with paint is being discussed, it is interesting to note, as reported by the *Lancet*, that a serious epidemic occurred in 1911 at Stockholm, in a block of houses which were converted into Government offices, which has been traced to arsenical poisoning. Of the 200 officials in the building, 143 developed symptoms of a more or less similar nature. These symptoms quickly ceased when the patients took a holiday. At the first this outbreak was traced to neurasthenia, or over-work, but at the beginning of 1912 arsenic was suspected, and ultimately found in the paint on the walls, by one of the officials. On repainting the walls the patients soon recovered their health.

Professor Lennmalm and two chemists were appointed by the Government to investigate the causes of the outbreak. The examination of the

patients' urine frequently revealed large quantities of arsenic. This gradually disappeared when the patients were given a holiday, but reappeared on their return to work.

An analysis of the paint on the walls showed the presence of 648 mgms. of arsenic to the kilogram, and paint scraped off 200 sq. cms. of the wall yielded as much as 3.948 mgms. of arsenic. Presumably for the sake of economy Dutch zinc-white had been used, which contained large quantities of arsenic.

It is also stated that considerations of economy were apparently responsible for the use of a great quantity of turpentine with the oil used in the paint. For this reason it failed to dry quickly, and could be rubbed off with the finger long after it had been applied. The symptoms observed were more severe in cold seasons of the year, and when, as in summer, the windows were open, there were relatively few complaints.

Arsenical gases were set free by certain moulds, which were observed in large quantities. It is interesting to note that arsenical poisoning frequently occurs in Sweden, and that this is largely ascribed to erratic legislation. It is even stated that 8% of the patients in the outbreak described had previously suffered in a similar manner.

Flax Growing.

The announcement has been made of further arrangements for an investigation into improvements in the growing of flax, and in methods of retting. The Development Commissioners have asked the University of Leeds to undertake the preliminary arrangements connected with this step, and it is said that 120 acres have been sown with various selected types of seeds at Selby. The establishment of a central rettery is also being considered, where the various crops may be treated. The Treasury has sanctioned a grant from the Development Fund to cover the cost of this extension, which naturally follows on the preliminary investigations which have been carried out by Dr. J. Vargas Eyre. The question of the subsequent erection of an experimental station is still under consideration.

The investigation of this problem is one which will necessarily present many difficulties. The retting process itself is complicated, and certain difficultly recognisable factors have given the waters of certain rivers properties which have been specially utilised for this process. The process of retting, itself, depending as it does upon bacterial action, is also of a nature which requires extended and careful investigation, and it is therefore satisfactory to note that the Development Commissioners have decided to give further consideration to this matter.

It must be acknowledged generally that the work of the Development Commissioners and that which may be expected under the recently announced Medical Research Fund, marks a definite step in the acknowledgment by politicians of the claims of research and its bearing on general conditions. It is altogether to the credit of those responsible that such steps have been taken, which can hardly fail to act favourably in the interest of science.

ELECTRICAL AND THERMAL DISINTEGRATION OF METALS.

By G. W. C. KAYE, B.A., D.Sc., NATIONAL PHYSICAL LABORATORY.

(Continued from page 185.)

Volatility of Carbon.—The question of the volatility of carbon has interested a number of workers from time to time. Some recent experiments of Harker and Kaye at the National Physical Laboratory may be mentioned in this connection. A carbon tube was heated by an alternating current to about $3,000^{\circ}\text{C}$. in an atmosphere of hydrogen. In running up to such high temperatures, the silica



FIG. 11.—VOLATILISED SILICA.

and lime which are present as impurities in commercial carbon distil off at about $2,000^{\circ}\text{C}$. These collect at the cooler ends of the tube sometimes in beautiful stalactitic deposits. Fig. 11 shows a diaphragm of silica which was so obtained; it was photographed *in situ* by the light of the hot tube. For the present experiment the impurities had been removed in a previous run. Down the centre of the carbon tube was mounted a metal tube which was kept cool by a rapid stream of water. At the end

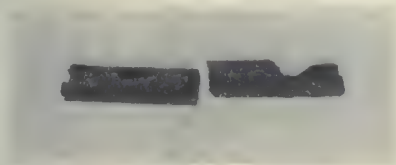


FIG. 12.—VOLATILISED CARBON.

of half an hour or so the metal tube was withdrawn and found to be coated with a deposit of carbon hard enough and coherent enough to be slid off in short lengths. Fig. 12 shows two samples of such carbon. The method may prove to be a means of obtaining carbon of a purity unattainable by other methods.

In passing, it may be mentioned that the apparatus possessed further interest as a means of generating electricity direct from heat.¹ A large difference of temperature between the two tubes proved to be

the only essential condition for success. On joining the hot carbon tube to the cold metal tube through a circuit containing a current-measurer, electric currents, amounting in some instances to several amperes, were obtained. The direction of flow of the current was opposed to that of the heat. *A propos* of the behaviour of carbon at high temperatures, Harker and Kaye, by applying lateral strain to a carbon rod heated electrically to $2,500^{\circ}\text{C}$. or so, have recently been able to secure distinct evidence of the plasticity of carbon at such temperatures. Fig. 13 shows a sample of carbon rod before and after the experiment.

Straight-line Emission of Particles.—It will have been realised that the deposits we have noticed

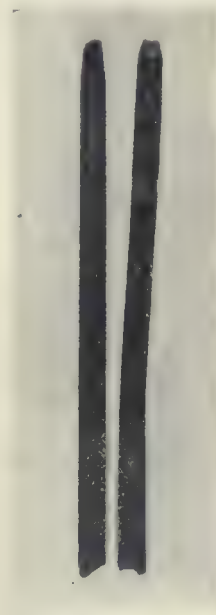


FIG. 13.

hitherto have all been examples either of chemical action between the gas and the metal, or of true sublimation. But some recent experiments of Reboul and de Bollemont (*Journ. de Phys.*, July, 1912) show that this is not a complete statement of the case, and that there are instances of the emission of sputtered particles at right angles to the surface of the heated metal, in much the same way as in cathodic sputtering. Their experiments were carried out in an electric furnace; two small sheets of metal were mounted facing each other a few millimetres apart in the furnace. One sheet (A) acted merely as a receiving screen; it was usually of platinum, but its nature was not important. The

¹ See Harker and Kaye, *Proc. Roy. Soc.*, 1912.

other sheet (B) was made of the metal whose disintegration was being studied. The furnace was heated to temperatures between 400°C . and 900°C .; below 400°C . no effects were obtained. In these circumstances the authors found that if sheet B was of copper or silver, a black deposit of the same size and shape as B was produced on the screen A, provided the distance between the plates did not exceed

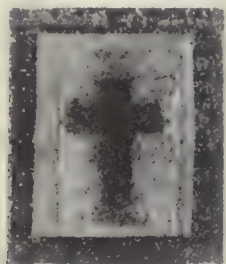
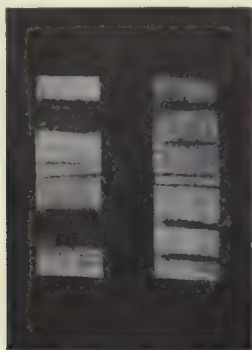


FIG. 14.

about 3 mm. At greater distances no deposit could be detected; the heaviest deposits and the sharpest outlines were secured when the two sheets were no more than about 1 mm. apart. Fig. 14 shows the deposit obtained in air at atmospheric pressure from a copper sheet of the form of a small cross. The temperature was 850° , the distance 1 mm., and the time of exposure 30 secs.

The experiments were carried out in air, oxygen, nitrogen, hydrogen, and carbon dioxide; the effects were enhanced in oxygen and feeble in CO_2 . The deposit proved to consist either of the sputtering metal or its oxide. In a vacuum, the sharpness of outline of the deposit was considerably increased. In hydrogen, curiously enough, the edges of the strip seemed to be the only active regions, so that the

FIG. 15.—AIR, H_2 .

sputtered image reproduced merely the outlines of the strip. The effect may be contrasted with the case of cathodic sputtering dealt with on p. 152. Fig. 15 shows the difference between the copper deposits obtained in air and in hydrogen under identical conditions of experiment.

The temperature of the furnace exercised an important effect, and the rate of deposition increased

very markedly as the furnace was made hotter. With continued heating, the deposit disappeared again—possibly if the screen had been maintained cooler than the furnace this would not have occurred.

The copper was found to “fatigue,” and on a second heating yielded a much feeble deposit. The authors tried other metals—nickel, iron, and aluminium—but the phenomena could not be repeated in these cases.

Reboul and de Bollemont suggest as an explanation of these effects that the occluded hydrogen and oxygen in the metal are caused to combine explosively by the heat, and in consequence loosen particles of metal from the surface which are projected over a short range. This, of course, would explain the fatigue effect, and the influence of oxygen on the depth of the deposit. The authors also seek to correlate the effect with the well known emission of positive electricity when copper and silver are heated at such temperatures. The point should not be lost sight of, but it may be added that copper and silver share this property with almost all bodies, and so far as the present experiments went, the attempts to extend the sputtering to other metals did not succeed.

Ewen, Harker and Kaye at the National Physical Laboratory, have recently obtained evidence of similar rectilinear emission of particles in the case of iron, iridium and tungsten.

Size of the Particles.—Houllevigue, by heating a gold wire *in vacuo*, obtained deposits of gold on glass which were thin enough to show by transmitted light the violet and pink colours characteristic of colloidal solutions of gold. In such solutions, the smallest particles have diameters from $(3 \text{ to } 6) \times 10^{-7} \text{ cm.}$ —much the same as in glasses coloured by gold.

Roberts examined some of the black deposits obtained by heating platinum in air at pressures from 500 to 600 mm. A high-power immersion microscope revealed a vast number of black particles resembling soot, and of sizes ranging from 10^{-8} cm. to $2 \times 10^{-6} \text{ cm.}$ Just as with cathodic sputtering, no semblance of crystalline structure could be detected.

Kohlschütter and Ehlers (*Zeit. f. Elekt.*, May, 1912) have paid special attention to the distillation of zinc, cadmium arsenic and selenium, both *in vacuo* and in various inert gases such as hydrogen, nitrogen, carbon dioxide and sulphur dioxide, for a range of pressures extending from about 50 mm. to 900 mm. By microscopic examination of the deposits, they found that the higher the pressure of the gas, the smaller and more closely packed were the condensed particles. *In vacuo*, the deposits were smoother and more compact than at higher pressures. Under the same conditions of pressure, the subdivision was finest in the denser gases, as though the heavier gas molecules were competent to shatter and disperse the metallic particles.

Kohlschütter and Ehlers found that for all the metals they tried the sizes of the condensed particles were very much the same under the same conditions. These diameters were approximately as indicated in the following table.

Fig. 16, taken from Kohlschütter and Ehler's

paper, will give an idea as to the appearances of four of the deposits in the case of zinc. The magnification is about fifty times.

Practical Applications.—The method of thermal deposition is of easy application with almost any metal for the manufacture of either films or sheets of metal. It is essential, of course, to keep the receiving surface sufficiently cool. To obtain bril-

liant coherent mirrors, more especially with oxidisable metals, a high vacuum is to be recommended—not more than 1 or 2 thousandths of a millimetre.

One convenient plan with the more refractory metals, such as Pt, Au, Fe, Ni, is to stretch at a few centimetres distance above the receiving surface a grid of wire through which a suitable heating current can be passed. Houllevigue recommends rotating the surface to be metallised to secure uniformity of

Gas.	Pressure.	Diameter of Particles.
	mm.	mm.
Vacuum..	0	0—0.5
H ₂ ..	60	0.1—0.2
	870	0.02
N ₂ ..	60	0.05
	870	0.01
CO ₂ ...	60	0.1
SO ₂ ..	800	0.005
	50	0.01

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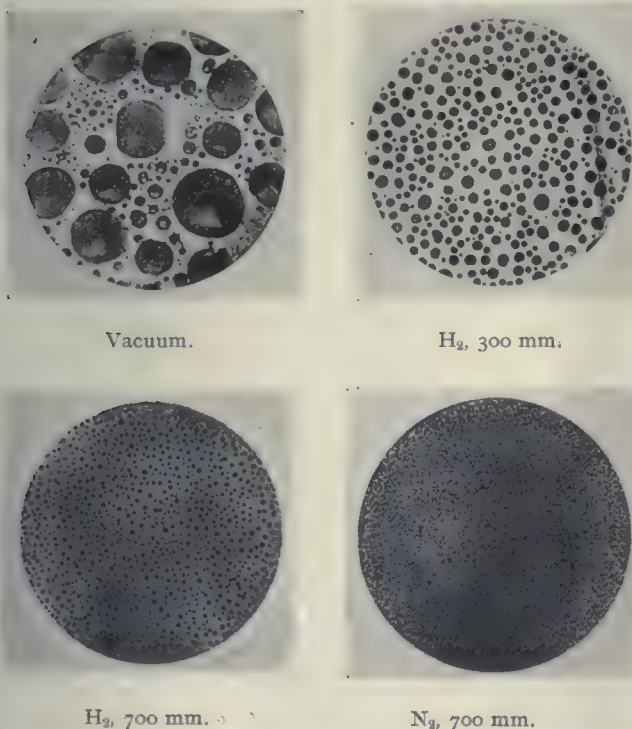


FIG. 16.—PARTICLES OF VOLATILISED ZINC.

deposit. With metals which melt at moderate temperatures, Houllevigue uses a composite wire, made up of a platinum or iron core, on which is deposited the metal in question. With oxidisable metals, the receiving surface can be screened at first



FIG. 17.—RESIDUE FROM DISTILLED BRASS.

wound with platinum foil, which can be heated electrically, serves excellently. It is convenient to control the exposure by bringing up the receiving surface to the furnace for the length of time required. The volatilised metal can be deposited either as films or as thick sheets on any suitably cooled surface. The method is especially valuable in the case of those metals which are not amenable to the usual methods. Pohl and Pringsheim (*Ber. Deut. Phy. Ges.*, 1912) have, by this means, obtained very brilliant mirrors of beryllium, magnesium, aluminium, calcium, silver, iridium and cerium. Hughes (*Phil. Trans.*, 1912) at the Cavendish Laboratory, has been similarly successful with zinc, cadmium, lead, arsenic, antimony, bismuth and selenium.

Alloys.—The method of distillation *in vacuo* promises to find considerable application, both in the synthesis and analysis of alloys. For example, Berry, at Cambridge, has used the method to prepare MgZn₂, by distilling magnesium with excess of zinc *in vacuo* until the excess is driven off. By then adjusting the conditions, the alloy can be volatilised and condensed without decomposition.

In other cases the plan can be employed for splitting up and so analysing alloys, *e.g.*, brass, German silver, and alloys of copper with lead or cadmium. Brass separates completely into its constituents when heated in a vacuum; the zinc distils over readily at 500° or 600° C., leaving the copper behind. The copper does not come over until a much higher temperature—1,100° or 1,200° C.

Fig. 17 shows the residue from a sample of brass which was distilled in an Arsem vacuum furnace at the National Physical Laboratory. The zinc

evaporated and the sample shown is almost entirely copper of brilliant lustre.

Some Properties of Metal Films.—The tendency of thin metal films to increase in transparency by drawing up spontaneously into isolated thickened patches at the expense of contiguous thinner regions has already been noticed (p. 151). The effect which suggests that the film is possessed of a kind of surface tension is enhanced by a rise in temperature. Turner (*Proc. Roy. Soc.*, 1908) has shown that silver and gold leaf, when heated to about 500° C., similarly become quite clear and transparent. Microscopic examination shows that the film draws up and forms a large number of holes, through which the light is transmitted.

Some of the less evident changes which take place in metal surfaces can be gathered from their ability to emit electrons when a beam of light is directed upon them. In the case of freshly prepared films this photo-electric activity was found by Pohl and Pringsheim to be restricted to ultra-violet light, whose wave length did not exceed about 4,000 A.U. (*i.e.*, at the violet end of the spectrum); the effect increased continuously as the wave length was shortened. But by the end of a few hours the film gained in activity, and the range of effective wave lengths was no longer restricted to the ultra-violet, but extended well into the visible spectrum, and even into the infra-red. For example, the effect could be detected in the case of a film of aluminium up to a wave length of 7,000 A.U. (in the extreme red), and with magnesium up to 10,000 A.U. The activity was, however, still most pronounced with the ultra-violet rays, and attained a maximum for a wave length of about 2,600. After some days the sensitiveness of the film for the long waves gradually disappeared, and the photo-electric effects became confined to the ultra-violet once more. Pohl and Pringsheim attribute this to the effect of occluded

gas, which is liberated from the various materials within the vacuum. In support of this view, they mention that, if air was admitted into the apparatus while the film was in its most sensitive condition, and the vacuum was again restored, the metal lost almost all its photo-electric activity, and did not recover it for some little time. It would seem to be easy to provide a check on this explanation, by taking steps to remove the occluded gas as fast as it is liberated.

In conclusion, the conveniences of the cathodic and thermal methods of making thin films of metal will be evident when one contrasts them with the older methods. The art of the gold-beater is restricted to gold, silver, aluminium, platinum, and copper. Leaf as thin as (11 to 40) $\times 10^{-8}$ cm. thick can be obtained with these metals. The leaf is not, however, by any means uniformly thick, even over the same sheet.

Electro-plating is only applicable to a receiving surface naturally or rendered electrically conducting. In addition, a few metals lend themselves to other methods, *e.g.*, silver and copper, by reduction of solutions of their salts; platinum, by igniting a platinum salt; nickel, by heating nickel carbonyl, and so on.

By means of the sputtering methods, practically any metal may be deposited to any extent on any surface, and the attention the subject is at present receiving will doubtless result in applications of extended practical value. In this connection, mention should be made of a method of spraying surfaces with metal. The surface is placed a short distance from an oxy-acetylene flame into which is inserted a piece of wire of the metal to be employed. The blast of the flame drives the vaporised metal on the surface where it condenses. Practically any substance can be metallised in this way; for example, bone or celluloid can be gold plated.

COLLOIDAL METAPHYSICS v. COLLOIDAL PHYSICS.

By EMIL HATSCHEK.

THE procedure which Mr. Cross adopts in his paper, "The Elusive Colloid," in the June number of this journal towards the recent discussion of the Faraday Society involves the drawback of shifting the trial of such issues as he raises from a competent and summary tribunal, as it existed at the conference, to one presumably less competent and certainly less prompt.

This is, of course, merely a formal objection to Mr. Cross' presentation of his case. As regards its merits, it begins by differentiating between, "the viscosity of colloids," and "the viscosity of colloidal systems." I do not know whether this is a reproach to us for not having treated the viscosity of *solid* colloids. The somewhat singular delusion that elastic solids can also possess viscosity does, I know, exist in some quarters, but there is no direct evidence

that Mr. Cross shares it. If he does not, the objection really seems somewhat artificial, as it was obvious that only the viscosity of liquids, *i.e.*, of colloidal solutions could be the subject of discussion.

The desire for "clear definition" expressed in the same passage, is one I share, but I must confess to finding it somewhat incongruous in its environment, in a paper the obscurity of which is in places such as may without injustice (and I hope without offence) be called apocalyptic. The general impression it leaves, however, is that Mr. Cross would ignore what we are doing, either in regard to the immediate subject, viscosity, or in the whole field of colloidal chemistry and physics. He calls viscosity "a complex unrelated property," and fails to see that the meeting endeavoured to unravel this complexity, and to establish relations between viscosity

and other factors, such as concentration, degree of dispersity, ionisation, etc. This is an object which may not appeal to, or interest, everybody, but its importance for the progress of science—as we conceive it—cannot be denied.

As regards colloidal chemistry and physics generally, Mr. Cross' views, and their divergence from those of most modern investigators, are excellently illustrated in two consecutive sentences: "How best to attack the central problem of the *colloidal state*? The chemist is primarily concerned with types of *colloidal matter*" (the italics are mine). Modern colloidal science deals only with the colloidal state, a state in which, by appropriate methods, practically *any substance* may be obtained. The colloidal state to us is, roughly, one of such fine subdivision, that certain factors which depend on the surface assume preponderance, owing to the increase of surface due to the subdivision. Modern science does *not know* "colloidal matter," or colloids in Graham's sense, although it uses the term colloquially. *A fortiori* it knows no "prototypes" of such matter, but only *types of colloidal solutions*, of which, say, a gold sol is one, and a silicic acid sol another.

Mr. Cross, on the other hand, talks of colloids as a class of compounds, exactly as one might speak of ketones or of carbinols, and as prototypes of this class proclaims starch and cellulose. The following is therefore a concise, and, I think, rigorously fair (if crude) statement of his position, as I understand it:—

Starch and cellulose are the prototypes of colloidal matter.

Modern colloidal science has not sufficiently concerned itself with these prototypes.

Ergo: Modern colloidal science is on the wrong track.

If these propositions, and especially the major, were indeed true, I should at once admit, in the words of Hudibras, that

"Colloidal chemistry had caught
The itch, on purpose to be scratched."

However, I entirely deny the major proposition. As already explained, we do not know such a concept as colloidal matter. But I am ready to waive this point for the purposes of argument, and to assume that there *may* be prototypes, or to use even more metaphysical language, archetypes of such matter. If so, few substances could be less qualified to figure as such than cellulose. To be the type of a class, an object must have as many characteristic properties as possible in common with all other members of that class. Now cellulose, as nobody knows better than Mr. Cross, has a very large number of properties which are entirely unique. He himself instances one: "... we have the striking fact that we can introduce negative groups into the system, e.g., $O.NO_2$, $O.C_2H_5O$ with an increase of weight of 70% to 80%, and with no sensible change of structural colloidal properties." (N.B.—In passing, one may raise the question whether the solubility of nitrocellulose in many media in which cellulose is

insoluble, the different behaviour in polarised light, etc., do not indicate a change in these properties.)

Now this very striking property belongs, as far as I know, only to starch and cellulose. That such bodies should *therefore* be used as types and called in to elucidate the properties of colloids, strikes me as a singularly infelicitous inversion of the methods by which science has generally progressed.

It is also evident, that speculations about the chemical constitution of such singular bodies cannot be expected to advance our general knowledge of the colloidal state. I am not at all competent to discuss the propositions that polymerisation, anhydride formation, etc., explain the differences between starch and cellulose, but quite competent to say that, even if proved up to the hilt, they would in no way help us to understand such systems as, say, a gold sol, an arsenic trisulphide sol, and a silicic acid sol, to take three classical instances, the investigation of which, largely by physical methods, has enormously advanced our knowledge of the colloidal state.

Mr. Cross' general grievance—the alleged neglect of the purely chemical side of colloidal science—is one with which I must confess myself out of sympathy. The general trend of investigation in any subject shows in what direction competent workers conceive progress to be most probable or fruitful. In this connection, I may quote Professor Lottermoser, who speaks with some authority: "It is clear that in this field (viz., colloidal chemistry) of chemical science, exactly as in its other branches, only the application of physical methods still promises success" (*Chemiker Zeitung*, April 10th, 1913). But if the eclipse of the chemical side is to disappear, it is necessary "que Messieurs les chimistes commencent." If Mr. Cross is convinced that the study of the hexose derivatives is the road to an improved colloidal science, I submit that it is for him to give us these investigations. The alternative would be much less satisfactory: someone else would first have to acquire the vast body of knowledge about cellulose which Mr. Cross already possesses, and has, indeed, largely created, and would then have to apply it according to his own light. This is not either the usual or the most economical way to advance science. The specialist must master the general discipline, not *vice versa*. It has been found advisable to apply mathematical methods to chemistry, but this has not been done by mathematicians who learned chemistry, but by chemists who (however reluctantly) acquired a knowledge of mathematics. In any event, I can recollect no case in the history of science in which progress was initiated by someone who simply took up the attitude of pointing the way without going it.

Hosiery of Artificial Silk.—Hosiery of artificial silk is being manufactured on a considerable scale in Chemnitz. The local correspondent of the *Textile Mercury* writes that coloured artificial stockings are competing seriously with pure silk tram goods. The manufacturers double the artificial silk on to a very fine quality of mercerised lisle.

ARTIFICIAL TANNINS.

By EDMUND STIASNY, PH.D.

THE development of the leather industry in the last few decades can be traced back to two distinct causes: firstly, the introduction of machine work, followed by a higher form of organisation of the manufacture in general; and, secondly, the influence of scientific views on the existing working methods and the invention of new processes in the production of leather.

As to this latter point, the greatly increased number of vegetable tanning materials must be mentioned, followed by the invention and splendid development of the chrome tannage, the use of formaldehyde and quinone as tanning agents, and the many new processes used in the preliminary stages of leather manufacture, when preparing the hides for the actual tanning processes.

There is, in spite of this rapid development, a distinct empirical character attached to this industry and it is the vegetable tannage which is most responsible for this deplorable fact. The reason for this state of things is our insufficient knowledge on vegetable tannins in general, and the almost complete failure to explain the specific action of each individual tannin and the distinct differences in the tanning effects of the different materials. It is not even understood if the chemical constitution or whether some physical properties are more responsible for the specific tanning capacity of the various tannins.

Two ways seem to exist which may lead us out of this unsatisfactory state of affairs. The one means a thorough study of the existing vegetable tannins as regards their chemical constitution, their physical properties, and their behaviour with chemical changes. This way, though highly interesting from a scientific point of view, will be a slow and laborious one, and the results may be of more theoretical than practical value. The other way is directed towards the production of synthetic substances of known chemical constitution and of the capacity of converting hide into leather. Some such synthetic products, which in some respects will be similar to, if not identical with, natural tannins, may have the further practical importance of being obtainable at such prices that they can compete with the natural products.

It is such a solution of the problem which has been found lately by the author, by the production of "syntans" (synthetic tannins), and one of the products is placed on the market by the Badische Company, Ltd., under the name of "Neradol D," the word "Neradol" being registered as a trade mark.

Syntans are condensation products, which can be produced either by heating phenols with formaldehyde in a slightly acid solution and solubilising

the resinous products thus obtained by means of sulphuric acid; or they can be made by first sulphonating the phenols and then condensing them with formaldehyde under such conditions that only water soluble products are formed.

Neradol D, the commercial product referred to, resembles in its appearance a vegetable tannin extract of bright colour. The analogy between Neradol D and natural tannins is evident by the following behaviour of Neradol D: Its aqueous solution is of a semi-colloidal character, passing a semi-permeable membrane only slowly and giving a precipitate with gelatine solution. Iron salts produce a deep bluish-violet coloration, and a 10% solution of iron alum is a suitable means of controlling the course of Neradol D tannage; this is done by placing a few drops of the iron solution on the fresh cut of a half-tanned hide, when the tanned layers are coloured deeply blue. Lead acetate as well as aniline hydrochloride give precipitates with Neradol D.

Special mention may be made of the very bright colour of Neradol D solutions and of the complete solubility in cold water, as these two properties mean distinct advantages over the ordinary tannin extracts.

As to the capacity of converting hide into leather, which, of course, is the most important analogy between Neradol D and natural tannins, a simple experiment with a piece of pelt will soon show the speedy and still gentle mode of action by which the pelt is quickly penetrated, and the grain nicely tanned, without being drawn or coloured. It is this entirely white colour of the Neradol D leather which is one of the striking features of this material, and which is of practical value, not only if Neradol D is used as the only tanning material, but also in combination tannages with Neradol D and any vegetable tannin, when the colour of the tannage is considerably brightened.

Neradol D can also be used with advantage as a bleaching agent of dark-coloured leather, and here the retanning action of this artificial tannin prevents loss of weight, which accompanies most of the usual methods of bleaching heavy leathers.

The real character of Neradol D is, however, that of a light leather tannin, and Sumach or Gambier are those natural tannins whose tanning effects have the greatest resemblance to that of Neradol D.

There is a great variety of ways of applying Neradol D, alone or in combination with other tanning materials, such as chrome salts, alum, and even wood pulp, and practical tanners will no doubt soon find their own methods of using the new material, and they will soon establish the new routine which is necessary with any new material.

PROFESSOR ADRIAN J. BROWN, M.Sc. (BIRM.), F.R.S., F.I.C.

By T. H. POPE, B.Sc., A.C.G.I., F.I.C., Lecturer on Brewing, Birmingham University.

THE British School of Malting and Brewing, now a Department of the University of Birmingham, was founded in the year 1899 in connection with Mason University College, which formed the original nucleus of the present University.

The School owes its existence to the munificence of a number of members of the brewing industry of Great Britain who recognised the advantages conferred by similar institutions on the fermentation industries of Continental countries. During the past few years the greater part of the funds necessary for the maintenance of the School has been provided by the brewers of Birmingham and its immediate neighbourhood.

The School buildings form a part of the Edmund Street branch of the University, and comprise: a main students' laboratory, containing working places for upwards of twenty students and well equipped with special apparatus suitable for the study of general brewing and bacteriological subjects; an analytical laboratory, adapted more especially for the examination of brewing materials; a microscope room and departmental library; a balance room; a dark room for polariscopic and photographic purposes; a research laboratory, and a lecture room.

The courses of study in the School are, to a large extent but not entirely, technical in character, and on the purely scientific side include biochemistry in its relation to fermentation.

A Diploma in Brewing in connection with the School is granted by the University to students who pass successfully through studies covering a period of three years. During the first two years preparatory instruction is given in the University Departments of Chemistry, Physics, Botany, Engineering,

Geology and Bacteriology, in addition to an elementary brewing course, while the whole of the third year is devoted to the science and technology of brewing. Shorter courses are arranged for brewers and maltsters unable to attend the complete Diploma course.

A Degree course in the Biochemistry of Fermentation is provided for

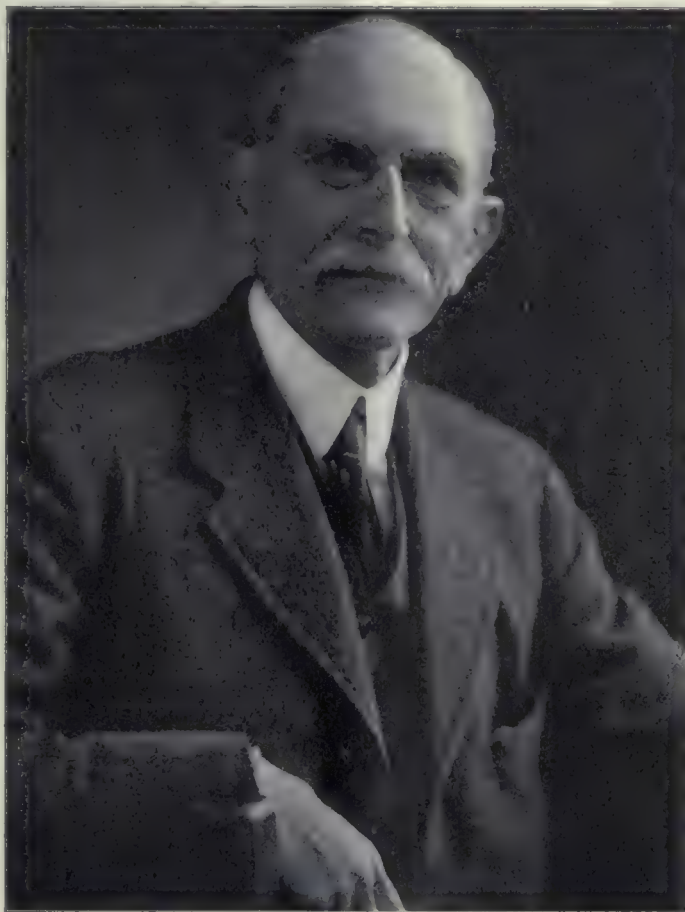
students who contemplate taking up biological or chemical work connected with the fermentation industries, agriculture, water supply, treatment of sewage, etc. This course occupies one University year, and includes lectures on enzymes and fermentation organisms by Professor Brown, and on the chemistry of the carbohydrates and proteins by Mr. T. H. Pope, together with corresponding laboratory work.

The principal course of lectures on Brewing Technology to third year students is given by Professor Brown, and a short course on the Sugars, etc., by Mr. Pope.

Professor Adrian J. Brown, M.Sc., F.R.S., has been Director of the School since its foundation, and his previous somewhat exceptional experience has fitted him peculiarly well for a position re-

quiring at once scientific and expert technical knowledge. After finishing his studies at the Royal School of Mines under Dr. (afterwards Sir) Edward Frankland, Adrian Brown acted for two years as assistant to the late Dr. W. J. Russell, F.R.S., at St. Bartholomew's Hospital, and subsequently entered the brewery of Messrs. Thos. Salt & Co., Burton-on-Trent, where he served for a number of years both as brewer and as chemist to the firm.

His first association with the brewing industry, which followed closely on Cornelius O'Sullivan's



PROFESSOR ADRIAN J. BROWN, F.R.S.

rediscovery of the sugar maltose as one of the products of the action of diastase on starch, occurred at a time when Pasteur's classic work on fermentation was beginning to attract attention and when the progress of science was just giving an insight into the complex changes of brewing processes. At this period, Burton's premier industry numbered among its scientific workers, besides O'Sullivan, such masters as Peter Griess, F.R.S., of diazo fame, and the brother of the subject of this notice, Horace T. Brown, F.R.S.

In addition to superintending the very considerable amount of work involved in the scientific control of a large brewery, Adrian Brown found time to carry out various researches dealing with different phases of the fermentation industries, certain of these investigations now ranking as classics in the subjects of which they treat.

His earliest published work, which appeared in 1886, consisted of a study of the chemical actions accompanying the development of the acetic bacteria. One of the principal results of this work was a demonstration of the fact that the phenomenon of fermentation is selective and is intimately associated with the molecular structure of the substrate. Since that time this conclusion has been repeatedly confirmed for many different micro-organisms, but there is no doubt that Brown was one of the first investigators, if not actually the first, to recognise its significance. His experiments showed, for example, that, under the influence of *Bacterium aceti*, d-glucose undergoes oxidation to d-gluconic acid, whereas d-fructose is not affected by this organism. He found, too, that under similar conditions mannitol is oxidised to d-fructose,

formed the subject of a number of publications by Bertrand.

An especially interesting result of Adrian Brown's



FORD'S STILL.

This still was designed by Mr. J. S. Ford, F.R.S.E., for the preparation of water free from traces of copper such as are found in water distilled from an ordinary copper still. The body of the still and the cylinder which is immediately superposed to it and which contains a series of baffle-plates, are of copper, the whole of the remainder of the apparatus coming into contact with the steam or with the condensate being of pure tin.



RESEARCH LABORATORY.

work on these organisms was the transformation of an aldose into a ketose, d-glucose being reduced to mannitol and the latter then converted into d-fructose by oxidation with *Bacterium aceti*. In this case, too, it appears probable that Brown was the first chemist to demonstrate the possibility of such a change.

Much of Adrian Brown's time and thought was devoted to a consideration of the conditions governing the growth and functions of the yeast cell. His work in this direction led him to advance views concerning the influence of oxygen-supply on fermentation which many at the time regarded as unorthodox. These views, based on the observation that the most complete aeration attainable stimulates rather than arrests the fermentative activity of yeast, were, indeed, in direct contradiction to the dictum of the great Pasteur, who regarded fermentation as a phenomenon occasioned by "life without air." At the time when these results were published Pasteur was nearing the end of his illustrious career, but Duclaux took up the cudgels on behalf of his chief and what promised to be a fertile controversy commenced. Differences were,

whilst dulcitol remains unchanged. Another acetic acid organism whose characteristics and actions were investigated by Brown is the one which he termed *Bacterium xylinum*, and which, under the name of *Sorbose bacterium*, has of recent years

however, soon brought to an end in consequence of Buchner's discovery that alcoholic fermentation is

scientific investigations is that relating to the velocity of inversion of cane sugar by means of the enzyme invertase occurring in yeast. O'Sullivan and Tompson's previous study of this question had apparently indicated that the enzymic decomposition of cane sugar obeyed the ordinary law for a unimolecular reaction, but Brown showed that the velocity constants exhibited gradual increase as the reaction progressed. He found also that, in solutions of different sugar-contents, equal amounts of invertase invert approximately equal *weights* of sugar per unit of time. These results led Brown to formulate the theory that inversion of cane sugar is preceded by the formation, between the enzyme and part of the sugar, of a compound which subsequently decomposes into invert sugar and the original enzyme; the latter then enters into combination with a fresh quantity of cane sugar. This theory is generally accepted at the present time.

not directly a function of the life of the yeast, but is effected by an enzyme, zymase, separable from

In measuring the heat developed during alcoholic fermentation by yeast Brown overcame the difficulties inherent in the calorimetric investigation of a slow reaction on a



MICROSCOPE ROOM.



GENERAL LABORATORY.

the living cell. Brown's views thus received complete justification.

Perhaps one of Adrian Brown's most useful

small scale by employing as calorimeter a fermenting vessel in actual brewery use. The large bulk (many barrels) of liquid used, the thick layer

of frothy yeast formed at its surface, and the stout wooden casing to the thin copper of the vessel, all co-operated in reducing the loss of heat by radiation to a minimum.

Another interesting fact, brought to light by Adrian Brown, is that the barley corn and seeds of others of the *Gramineæ* are enclosed in a remarkable differential membrane which permits of the entry into the seeds of certain substances in solution in the surrounding liquid, whilst other substances are kept out. Most peculiar differences are shown in this respect; thus, sulphuric acid and sodium chloride do not traverse this membrane, whereas acetic acid, alcohol and mercuric chloride do so with great readiness. These results bear intimately, not only on the process of steeping which precedes

the germination of barley on the floor of the malt house, but also on much-debated questions touching on the theory of solutions. In this connection, the marked influence of temperature on the rate of absorption of water by barley has been studied in its relation to the temperature-coefficients of chemical reactions.

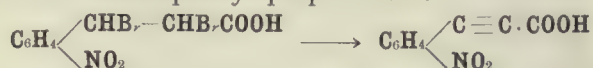
Professor Brown has recently been turning his attention towards hops and has been investigating a method for determining their relative preservative powers. This method is based on a particular lactic acid producing organism, the development of which, in cold water malt extract, is extremely sensitive to the presence of small proportions of an aqueous extraction of the hop.

SYNTHETIC INDIGO AND ITS DERIVATIVES.

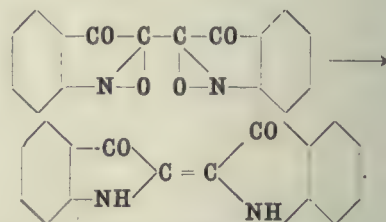
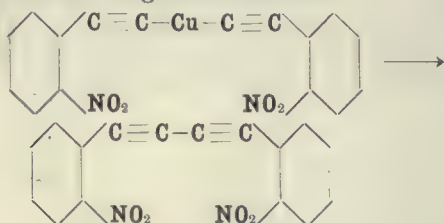
By E. DE BARRY BARNETT, B.Sc., A.I.C.

INDIGO has been used as a dyestuff since the earliest times, some Egyptian mummy cloths having been found to be dyed with it; and it has been discovered recently that the formerly much-prized Tyrian Purple is an indigo derivative. The great fastness of the shades and the enormous demand for the dyestuff led at an early date to many attempts at its synthesis. The first success was achieved in 1870 by Baeyer and Emmerling (B. III., 517), who obtained small quantities of indigo by heating isatine with phosphorus trichloride and acetyl chloride and then oxidising the product with air.

The next important step was the preparation of the dyestuff by Baeyer from *o*-nitro-cinnamic acid. This he effected by first saturating the double bond with bromine, and then treating the brominated compound with alcoholic potash, so as to form *o*-nitro-phenyl propiolic acid:—

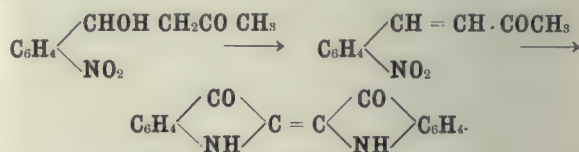


This was converted into indigo by two methods, viz.: (a) it was converted into isatine by boiling with caustic soda, and this then converted into indigo by reduction with an alkaline solution of glucose, or (b) it was boiled with water, when loss of carbon dioxide took place with formation of *o*-nitro-phenyl acetylene. The copper salt of this, on oxidation with ferricyanide gave the corresponding diacetylene, which, when treated first with concentrated sulphuric acid and then with ammonium sulphide, passed successively into diisatogen and indigo as indicated:—



Neither of these methods was successful commercially, although nitro-phenyl propiolic acid was used to a small extent for producing indigo directly on the fibre.

The next series of syntheses started from *o*-nitro-benzaldehyde and were due to Baeyer and Drewson (B. XV., 2856; XVI., 2205; D.R.P. 19,768). They found that the condensation product of *o*-nitro-benzaldehyde and acetone readily loses water to form *o*-nitro-aceto-cinnamone, which passes into indigo on treatment with caustic alkali:—

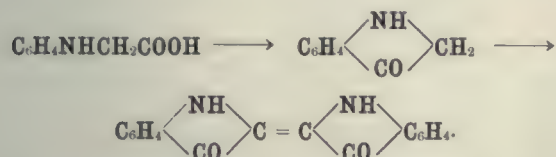


The bisulphite compound of the condensation product of acetone and *o*-nitro-benzaldehyde is used to a small extent in calico printing under the name of indigo salt. In this process the colour is developed on the fabric by treatment with strong caustic alkali solution.

None of the above syntheses have been commercially successful, as they all require toluene as a starting-out substance. Now in order to isolate 1 lb. of toluene from coal tar it is necessary to isolate about 4 lbs. of benzene, for which at present there is no outlet. This accounts for the rather high price of toluene—about 1s. 4d. a pound. If the high price of petrol causes benzene to be used extensively as a motor spirit there will probably be

a fall in the price of toluene. Another possible use for large quantities of benzene is for the production of isoprene (from which synthetic rubber can be obtained), but the experiments of the Badische Company have not yet gone far enough to show if this synthesis can be carried out successfully on the large scale (Cf. D.R.P. 252, 499). A further serious difficulty that is met with in all syntheses starting from toluene is that on nitration the *p*-nitro-compound is formed in addition to the *o*-nitro-compound, and hence it is necessary to find some use for the former. Some of it, of course, could find an outlet as *p*-toluidine, for which there is a limited demand in the dyestuff industry, or it could be further nitrated to trinitro-toluene, for which there is a considerable demand in the explosives industry, but it is very doubtful if the requirements of these industries would even approximate to the supply.

The commercial preparation of indigo is now exclusively carried out by Heumann's process (B. XXIII., 3043; D.R.P. 54,626). This consists in fusing phenyl glycine or phenyl glycine-*o*-carboxylic acid with caustic alkali, and then oxidising the indoxyl formed with air:—



As originally proposed this method did not seem very promising, as the yields did not exceed 8%, but the investigations of the Badische Company and of the Farbwerke vorm. Meister Lucius u. Brüning have improved the process so that the yields are now over 90%. These improvements have largely consisted in the addition of substances to the potash melt. It is impossible to mention all the additions that have been patented from time to time, but the greatest success has been obtained by using a mixture of caustic potash and caustic soda, with the addition of metallic sodium (D.R.P. 163,039), or sodamide (*ibid.* 137,955). Even after the yield from the potash melt had been rendered satisfactory, there were many other difficulties to be overcome. Thus, a method had to be devised for recovering the alkali, and this method is guarded as a trade secret. Further, the preparation of phenyl glycine required very careful investigation. When aniline is condensed with chloracetic acid, in addition to phenyl glycine, the diglycine ($\text{C}_6\text{H}_4\text{N}(\text{CH}_2\text{COOH})_2$) is also formed. This can be remedied to a large extent by carrying out the condensation in the presence of salt and ferric hydroxide, under which conditions the iron salt of phenyl glycine is formed, and as this is insoluble it separates out, and is thus protected from the further action of the chloracetic acid. Good yields of the ester can be obtained by condensing aniline with chloracetic ester, but unfortunately the ester can only be saponified by the expensive alcoholic potash. The amyl ester can be saponified by

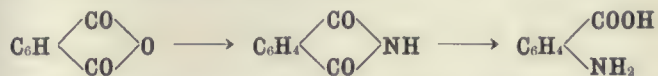
aqueous potash, but the high price of amyl alcohol mitigates against this method.

What is probably the most successful method of obtaining the glycines consists in treating aniline or anthranilic acid with the sodium bisulphite compound of formaldehyde, and then acting on the condensation product with sodium cyanide. By this means a nitrile is obtained which passes into the glycine on saponification:



In 1900, three years after the introduction of synthetic indigo into commerce, the Badische Company chlorinated 4,400,000 lbs. of glacial acetic acid, an amount equivalent to 130,000 cub. metres of wood. The use of such enormous quantities of chlorine rendered some cheap method of preparing the element very desirable. The electrolytic method was found to be the most satisfactory, and so much has it been improved, that chlorine is now almost a drug on the market.

Finally, as phenyl glycine-*o*-carboxylic acid was found to give better yields of indigo than phenyl glycine itself, an economical method for the manufacture of anthranilic acid had to be devised. Toluene, on account of its price, was out of the question as a starting-out substance, and so the Badische Company turned their attention to naphthalene, of which there is an almost unlimited supply at a low cost (about £7 per ton). This, they found, could be easily oxidised to phthalic anhydride by fuming sulphuric acid in the presence of mercury salts. Obviously in order to render this method commercially successful, it was necessary to recover the sulphur dioxide. This could not be done satisfactorily by the chamber process, but the contact process, which at that time was generally regarded merely as a chemical curiosity, although being worked secretly in this country by Messel, was found to solve the difficulty. The rest of the synthesis gave but little trouble. The phthalic anhydride by heating with ammonium carbonate was converted into phthalimide, and this on oxidation with hypochlorite (Hoffmann's reaction) gave the desired anthranilic acid:



The development of the synthetic indigo industry has been one of the classics of industrial organic chemistry. The investigations extended over a period of twenty years, and the Badische Company state that they spent over £900,000 on research and plant before being in a position to place the dye-stuff on the market.

The introduction of the synthetic dyestuff met with much opposition from the dyers. Up to that time indigo dyeing was regarded as a difficult operation, and was carried out by empirical methods. These methods were handed down from father to son, and were cherished as valuable trade secrets. On placing the artificial dye on the market the

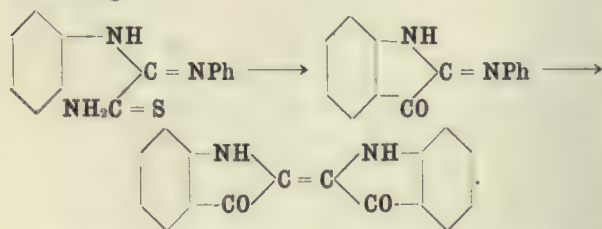
Badische Company undertook a detailed investigation of the whole subject, and, by the introduction of a stable form of sodium hydrosulphite, reduced the art of indigo dyeing to a science. This development was not altogether welcomed by those dyers who were in the possession of a satisfactory recipe, and theories were circulated that the lack of impurities, such as indirubin, rendered the synthetic article less valuable than the dyestuff obtained from natural sources. These theories were proved to be without foundation, and the artificial product is rapidly replacing the natural. Thus, in 1912, over 25,000 tons of indigo were exported from Germany.

The natural indigo industry might have been saved to a large extent had more scientific methods been used. The artificial dye is placed on the market as a 20% paste, which is very easily reduced to indigo white, and the shades obtained never vary. The natural dye is usually marketed as briquettes, which require prolonged grinding before use and, as the shade varies with the impurities present, the dyer has to waste considerable time in blending various consignments. Had the indigo planters employed more scientific methods of cultivation and manufacture, and had they joined hands to establish a general clearing house, where their products could have been ground and blended to a standard shade, the synthetic product would certainly have had a much harder fight for supremacy.

As stated above, Heumann's process is exclusively used for the technical production of indigo. An extremely interesting synthesis, which, however, has not proved a commercial success, is due to Sandmeyer. In this case the starting-out substance is aniline, which is first converted into thiocarbonyl anilide by heating it with carbon bisulphide. This is then treated with potassium cyanide, and the nitrile thus obtained converted into the corresponding thioamide by treatment with yellow ammonium sulphide:



This, on treatment with concentrated sulphuric acid, passes into α -isatine anilide, which, on reduction with ammonium sulphide, loses aniline and forms indigo:—



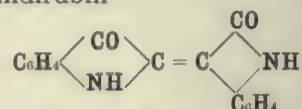
Although the yields at each stage are good, experience has shown that the process cannot compete with Heumann's synthesis.

The successful production of synthetic indigo naturally led to the study of its homologues and substitution products. The disulphonic acid has long been known under the name of indigo carmine, and was formerly used to a considerable extent as

an acid dye for wool and silk. Its use is now obsolete as, unlike indigo, the shades obtained are very fugitive.

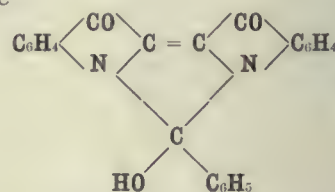
The halogenated indigos are of fairly recent introduction and have met with considerable success. Those halogenated in the *para*-position to the nitrogen atoms are very like indigo in shade, but rather brighter, whereas those in which the halogen atoms are in the *para*-position to the carbonyl groups are much redder. Thus Friedlander (B. XLII., 765) has shown that 6,6'-dibrom-indigo¹ is identical with Tyrian Purple. Much as this dye was prized by the ancients, it has not been found valuable enough to be placed on the market.

Of the technically valuable halogen indigos, 5-bromo-indigo is Indigo 2R and 5,5'-dibromo-indigo is Indigo RB or 2B. Ciba Blue 2B or Indigo 4B is 5,7,5',7'-tetrabromo-indigo. Pentabromo and hexabromo-indigo (Indigo 5B and Indigo 6B) are also known, but the slight solubility of their reduction products mitigates against their success. All the halogenated indigos are faster colours than indigo itself. In this connection it is interesting to notice that whereas indirubin—



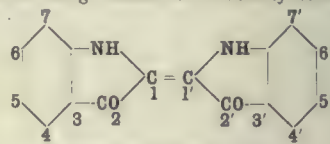
is useless as a dye, its bromo-compounds are fast colours, e.g. pentabromo-indirubin is Ciba Heliotrope. Of the homologues of indigo, only two are of importance. The 7,7'-dimethyl indigo prepared from the glycine derived from *o*-toluidine is Brilliant Indigo B or 4B, and a halogen derivative of the indigo derived from β -naphthylamine is Ciba Green G.

Of a different class is the yellow dye, Ciba Yellow, obtained by condensing indigo with benzoyl chloride in the presence of copper powder. It probably has the structure



and dyes in very fast shades.

¹ The atoms in the indigo molecule are usually numbered as follows



Palm Sugar.—It is not generally known that nearly half a million tons of sugar are produced yearly from the palm in India.

The juice has been found to contain eight to ten per cent. of sucrose associated with practically no glucose, which shows it to be an exceedingly good material for the production of white sugar direct from the juice.

The possibilities of the industry are further emphasised by comparison with the sugar produced in America from the juice of the maple which contains only three per cent. of sugar.—*Commercial Intelligence Journal*.

CHEMICAL ENGINEERING EXHIBITION.

THE holding of the first Foundry Trades Exhibition simultaneously with the second International Chemical Industry and Engineering Exhibition, from June 14th—28th inclusive, at the Royal Agricultural Hall, Islington, is a further indication of the increase of what may be called the "industrial diffusion" of chemical and mechanical science.

In finished products, the display of chemical materials as such constitutes the minor portion of the exhibition, yet that the paths of chemical research are being untiringly pursued is evident from the new departures. Among such, Messrs. Thomas Tyrer & Co., Ltd., show a very fine series of chemical products including resins, whilst the large range of their special preparations obtainable even include the rare gases.

The coal-tar colour and dyestuff industry is well represented by the exhibits of Messrs. Read, Holliday & Sons, of Huddersfield, who are doing so much to bring the industry back to this country, whilst the soap powders and samples of hydrogen peroxide and perborate shown by Messrs. Laporte, of Luton, are of great importance in laundry and textile work.

Seldom has the application of aluminium on a large scale been so well illustrated as in the vessels inseparable from industrial chemical plant, constructed from rolled sheet, shown by the Aluminium Plant and Vessel Co., Ltd. By substituting a process of autogenous welding for casting, soldering or riveting, the recognised physical advantages of rolled aluminium sheet, drawn rods and tubing can now be secured in vessels of any form and size, with sound joints, uniform and clean finish, and with comparative freedom from corrosion by organic acids, oils, waxes, foodstuffs, varnishes, perfumes, and the like.

National Alloys, Ltd., of Ilford, exhibit a light alloy "Ivanium," the strength of which is said to be 11 tons per square inch tensile, or about three times that of cast aluminium, though only 2½% heavier than pure aluminium. Unaffected by organic acids, sea-water, and sulphides, it is sound, close grained, and suitable for machining and castings of all kinds.

In passive irons, especially valuable in the manufacture of acids, the original "Tantiron" by the Lennox Foundry Co. and a material "Ironac" by Haughton's Patent Metallic Packing Co. command notice owing to the rapid way they are coming into use.

It is stated that the lack of mechanical strength of the original product has been overcome in both these products. In both cases the lining of vessels, cocks and valves with these substances and the variety of castings illustrating the numerous applications indicate that a non-corrosive iron with adequate strength must find an increasing market.

Sir W. H. Bailey & Co.'s exhibit of recording gauges, valves and acid pumps is representative of reliable British workmanship.

The varied examples of stoneware plant by Messrs. Doulton & Co. and Messrs. Skey & Co. meet many of the requirements of non-corrodible chemical plant, and the "Vitreosil" fused silica ware of the Thermal Syndicate is remarkable in resisting, under ordinary temperatures, all acids except hydrofluoric, though prolonged exposure to temperatures higher than 1,200 C. may cause deterioration.

The progress of science during the past twenty years is particularly indicated by the numerous protective and remedial appliances that have come into existence. Apart from the usual acid-proof garments and respirators for

operations in chemical and other industries, one must notice the various forms of portable apparatus for artificial respiration and for rescue work in mines and elsewhere. The exhibits of Messrs. Zimmer & Co., Mr. Richard Jacobson, and Messrs. Wallach Bros. are representative of such.

The water softening and purifying plants of Messrs. Lassen and Hjort, and the flue-gas combustion recorders of the Auto-Recorder Co. embody several minor improvements in their already effective apparatus.

The metallurgical microscopes, notably those with stereoscopic appliances for the observation of metallic fractures and unprepared specimens, by Messrs. Leitz, attract much attention, whilst there are numerous exhibits of scientific and laboratory apparatus, gauges, hydrometers, by Messrs. Townson and Mercer, Mr. Oertling, Dring & Fage, Brown & Son, and others, including distilling apparatus with noticeable improvements.

The medical and other applications of oxygen are well displayed by the British Oxygen Co. The oxyacetylene welding and metal-cutting processes shown by Messrs. Carbic, Ltd., together with the lead-burning plant for use with acetylene by the last-named, are of considerable interest. The portability, working cost, and the possibility of using air alternatively to oxygen, where the latter is unobtainable, are distinctly features that will commend themselves to the lead burner.

Both the oxyacetylene and acetylene air outfits are compact, and can be worked by one man. Compressed oxygen is not required in the acetylene air process. The Carbic acetylene generators have been adopted for motor and omnibus lighting. Carbic itself is a specially prepared and treated carbide, compressed into cylindrical cakes. These are impervious to atmospheric moisture.

Acetylene lighting systems have a rival in the Kitson Light Co. which employs suitable mantles heated to incandescence by vapourised paraffin.

The exhibit of the North Cornwall China Clay Co. deserves special notice on account of the superior quality of their product which stands very high in the markets' estimate.

The only exhibits connected with steam engineering are the Galloway-Hill boiler furnaces, adaptable to all classes of work and extremely simple in construction. The efficient burning of small coal and coal dust is facilitated by air conduits and induced draught and by a special form of bar bridge. An average saving of 15% in coal is claimed, and a practically smokeless combustion. The first cost of these furnaces is a fraction of that of the average mechanical stoker, and the simplicity is commendable. Messrs. Boosey also have a sectional furnace bridge, the "Unit," which improves boiler efficiency. A simple process for brazing cast iron without special appliances is due to the same firm, similar to which is the "Skolz" iron cement by Messrs. Major, Robinson & Co., Ltd., who also have some useful pipe and tube benders.

A solitary National gas engine represents the gas engineering section, though Mirreles-Leblanc air pumps, Reavel air compressors, hydro-extractors, vacuum drying and distilling plant are in fair prominence. The charcoal retorts, plant for wood distillation and grinding or pulverising machines by Messrs. Tattersall & Co., and the electromagnetic chucks, ore separators, and eye magnets by Messrs. Silversteen & Co. present some novel features.

The Britannia Foundry Co. show moulding plant, and the demonstrations of moulding processes as given by the Universal System of Machine Moulding and Machinery Co., and by the Adaptable Moulding Machine Co. do much to make one regard foundry problems in a new light.

With regard to the specimens of foundry materials and accessories, the exhibits of Messrs. Murphy, Steadman & Co. and of the Frodair Iron and Steel Co., and others are very varied, including a core binding compound recently introduced by the last-named firm and a process for renovating foundry sands and preventing waste by Messrs. Poulsen's, Ltd.

Messrs. Samuel Denison & Son, Ltd., exhibit some improved foundry testing machines for tension, compression and transverse tests, very compact in construction and effective in use. A neat method of hardness testing by indentation with a hardened steel ball, load and leverage being constant, is striking, the hardness of the metal being indicated to known scale by the diameter of the impression left by the ball, a special microscopic eyepiece for the observer being conveniently employed. The machines for testing such materials as cements and rubber are also of good construction, whilst the Denison-Korte briquetting machine for re-solidifying borings and machine tool waste into ingots of convenient size and form is another instance of the practical application of the modern industrial doctrine that all "waste" is material upon which surplus inventive genius may, with advantage, be expended.

Messrs. Thomas & Bishop exhibit their belt filler and preservative which enables belts to be run easy and at the same time increases the transmitting capacity. The belts running at the exhibition certainly indicate that this claim can be substantiated. The mixture "Cling-Surface" is said to contain no resin and is easily applied.

J. G. D.

PERSONAL AND OTHER NOTES.

CONSEQUENT on the resignation of Professor W. H. Perkin from the Chair of Organic Chemistry at Manchester University, on his acceptance of the Chair of Chemistry at Oxford, Dr. A. Lapworth has been appointed Professor of Organic Chemistry, and Dr. Charles Weizmann Reader in Biochemistry, and Lecturer in Colouring Matters at the Manchester University. Professor H. B. Dixon has been re-appointed Director of the Chemical Laboratories.

The President of the Institute of Chemistry announces that an anonymous donation of £2,500 has been offered towards the Building Fund, on condition that a further equal sum is obtained by subscription.

It is announced that Dr. G. Barger has been appointed by the Senate of the London University to the University Chair of Chemistry, tenable at the Royal Holloway College.

Nature reports that Dr. S. B. Schryver, biochemist at the Research Institute of the Cancer Hospital, has been appointed Assistant Professor of Biochemistry at the Imperial College of Science and Technology.

The Annual General Meeting of the Society of Chemical Industry will be held in the Arts Theatre of the University of Liverpool on July 16th, 1913, under the Presidency of Professor Marston T. Bogert, LL.D. On July 17th, 18th and 19th, various excursions have been arranged, and include such places as the works of Messrs. Lever Bros., Ltd., at Port Sunlight; the works of the United Alkali Co., Ltd., at Widnes; the shipbuilding works of Messrs. Cam-

mell Laird & Co., Ltd., at Birkenhead; the Diamond Match Works, at Seaforth; a whole day excursion to Chester; and a whole day excursion to Eskmeals, Cumberland. All communications relative to the meeting should be addressed to Dr. Alex. Rule, The University, Liverpool, not later than July 7th.

Dr. A. C. Houston discusses in the Ninth Research Report of the Metropolitan Water Board the influence of certain microbes in raw river waters and in crude sewage, in the distribution of typhoid bacillus. It is suggested that the danger of infection from the London Water Supply is infinitesimal. The danger of typhoid "carriers" has assumed a new and deadly significance, as compared with the relatively gross pollution from the sewage of a large community. The presence of a single individual of unknown health history is a danger which it is impossible to estimate. It has even been held that three or four out of every 1,000 persons are in this condition.

It is announced that the Cannizzaro prize of 10,000 lire, founded by the late Dr. Ludwig Mond, has been awarded by the Reale Accademia dei Lincei of Rome to Professor Frederick Soddy, M.A., F.R.S., for his researches in radio-activity.

At the last meeting of the Petrol Substitutes Joint Committee interest centred upon the suggestion to recover benzol from town gas, which has been recently emphasised by Mr. H. L. Doherty. In this respect a recent notice in the *Times Engineering Supplement* is of interest. In a series of tests conducted on London coal gas, in which the benzol was "scrubbed" out in a similar way to that adopted in coke-oven working, disconcerting results were obtained. The quality of the gas was so reduced as to render it unfit for consumption in the ordinary type of luminous jet.

The new laboratories of the National Physical Laboratory have now been completed, at an estimated cost, including equipment, of over £35,000, for which the Treasury has contributed £15,000. They include a new optical laboratory and further space for testing photometric and microscopical lenses.

In connection with the International Road Congress an exhibition of Road-making appliances and materials was held at Westminster, which included exhibits of spreaders, tar boilers, stone crushers, mixing plants, and also many proprietary articles, such as "Tarmac," "Rocmac," "Tarvia," "Roadoleum," and "Ferromac." The Val de Travers Asphalte Company, the Limmer Asphalte Company, and the Trinidad Lake Asphalte Company exhibited their various products.

Electric Smelting of Zinc.—It is stated in a report from the British Consul at Lyons that waterfalls at Arrhens (Hautes-Pyrénées), capable of generating electricity to the extent of 70,000 H.P., have been acquired by a company, formed with a capital of £160,000, to undertake the smelting of zinc ore by means of the electric furnace. The current will be transmitted to smelting works at Argelès, where at present from 16,000 to 18,000 tons of ore are produced yearly. As these works will not be ready for some time, an existing plant with water rights to the extent of 1,500 H.P. has been rented in Savoy, where it is proposed to manufacture white zinc.—*The Times*.

The Biochemical Society.—The next meeting will be held at the Rothamsted Experimental Station, Harpenden, on July 12th.

MOLECULAR PHYSICS.

By J. A. CROWTHER, M.A. (Fellow of St. John's College, and Demonstrator in Physics in the Cavendish Laboratory, Cambridge.)

CHAPTER V. (*continued*).

THE NATURE AND SIZE OF AN ELECTRON.

It makes itself apparent at the surface of the sphere when the motion of the latter is altered in any way.

We may very profitably extend this analogy further in that part of our proof which still remains to be considered, by thinking of our electric field in terms of tubes of electric force. This conception we owe to the genius of Faraday. Untrained in the methods of mathematicians, he found the mere algebraical expression for the laws of electrical attraction both unsatisfying and unstimulating. He felt that if two bodies attracted each other it could only be because of some vital bond between them. Thus he imagined that every positive charge was the beginning of a certain number of tubes of force stretching out through space until, somewhere or other, they ended up on an equal but opposite negative charge.

By assuming that these tubes were in a state of tension so that they tended to shorten themselves as much as possible, and, further, that two similar tubes repelled each other, he was able to give a clear explanation of the various electrical phenomena. Thus the attraction between two oppositely charged bodies was the result of the tendency of the tubes connecting them to contract; the repulsion between two like charges was due to the mutual repulsion between the tubes of force radiating from each of them. An electric current was the motion of one of the ends of the tubes of force along the conductor, while the magnetic effect in the neighbourhood of the current was due to the motion of the tubes of force through the surrounding medium.

The concentration of attention upon the phenomena of currents which marked the latter half of last century tended to throw somewhat into oblivion this conception of Faraday. The recent researches with which we are dealing have, however, found in it a most powerful weapon, and are tending to give to these tubes of force a definite significance and concrete existence of which even their originator perhaps hardly dreamed.

Let us add to the postulates already made by Faraday this additional assumption, that a tube of force when moving through the ether is able to grip a certain quantity of that subtle fluid, in much the same way that a cylinder carries along with it a definite mass of any liquid through which it moves. For a single charged particle at a considerable distance from any other attracting bodies the lines of force will radiate out in straight lines from its surface,

and, if the latter is spherical, the tubes will space themselves evenly around it owing to their mutual repulsion. In section, therefore, they will appear somewhat as in Fig. 16.

Suppose this system to be moving through space in the direction OA with a velocity v . If our analogy with the case of a body moving through water holds, the tubes, like OB, which move at right angles to their length, will grip the maximum amount of the ether through which they are moving, while tubes like OA, which are moving along their length, will carry none. It will thus be seen that the distribution of energy in the field surrounding the particle will correspond exactly with the distribution of energy in the electro magnetic field of which it is supposed to be a visualisation. The electrical mass of the particle will then be the whole mass of the ether gripped by these radiating tubes.

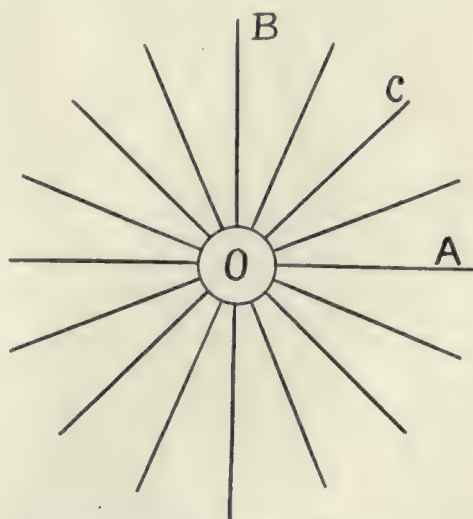


FIG. 16.—DISTRIBUTION OF TUBES OF ELECTRIC FORCE ROUND AN ELECTRON AT REST.

Now it is a well-known fact that a cylinder moving through a fluid in the direction of its own length is not in stable equilibrium. In accordance with the well-known principle of least action, the cylinder will tend to turn so as to offer the greatest possible resistance to the motion, that is to say, it will tend to set itself at right angles to the direction in which it is being compelled to move. If this holds for tubes of force travelling through the ether, then tubes like OA are not in stable equilibrium, but will tend to turn into the plane of OB, which we may call the equatorial plane. It can be shown from the principles of electricity that such a tendency does indeed exist. The repulsion between the different tubes will, of course, tend to keep OA in position, and, as this repulsion is very great, at moderate

velocities the effect we are considering will be quite negligible. The force, however, tending to displace the tubes increases with the velocity of the particle, so that at speeds approaching that of light there is a very perceptible shifting of the lines of force into the equatorial plane, as indicated in Fig. 17. But we have noted that the mass of ether gripped by the tubes in this position is greater than that which they originally held. Thus we arrive at the somewhat startling result that the electrical mass of a particle is not a constant, but depends, at any rate at high velocities, upon the speed with which it is moving.

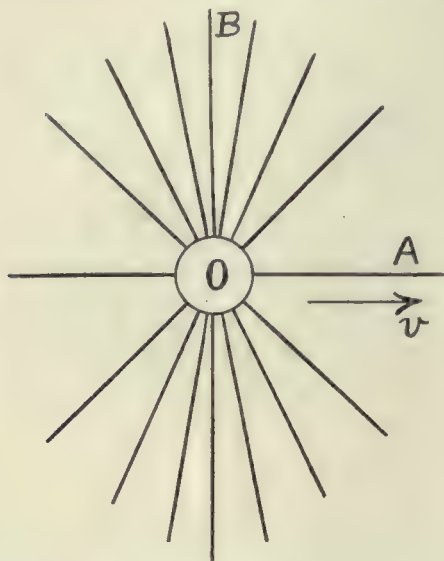


FIG. 17.—DISTRIBUTION OF TUBES OF ELECTRIC FORCE ROUND A MOVING ELECTRON.

We have followed out the theory of the variation of electrical mass from the standpoint of Faraday's tubes of force, because, in the first place it gives us at once a clear and vivid picture of the processes which are going on in the field, while, in the second place we are being gradually driven to the conclusion that some such entities do play a very important part in the phenomena of the electric field. The fact of the variation of electric mass with the speed, however, does not depend in the least upon the particular way in which we choose to regard the electric field, but is a direct though obscure consequence of the fundamental facts of the science.

The exact relation between the electrical mass of a moving charge and its velocity depends somewhat on the assumptions we make as to the distribution and geometrical configuration of the charge. Thus, starting from different ideas of the shape of the electron and the way in which its charge is arranged, different mathematicians have arrived at somewhat different formulæ for this relation. Fortunately, when these are reduced to figures the differences between the best of them are so small that our experiments are scarcely accurate enough to settle definitely between them. One of the most successful is that of Dr. Abraham, who deduces that

$$\frac{\text{electrical mass at a velocity } v}{\text{electrical mass for small velocities}} = \frac{3}{4\beta^2} \left(\frac{1 + \beta^2}{2\beta} \log \frac{1 + \beta}{1 - \beta} - 1 \right),$$

where β is the ratio of the velocity of the particle to the velocity of light.

Let us see now how these results assist us to discover the nature of an electron. The total mass of the electron may be made up of two parts: its mechanical mass, which is constant and independent of the velocity with which the electron is moving; and an electrical mass, which increases with the velocity in the way we have just considered. If the electrical mass of the electron is small compared with its ordinary mechanical mass, then there will be very little variation in the total mass of the electron as the speed is increased. If, on the other hand, the whole of the mass is electrical in its nature, the total mass of the electron should increase at the rate given by the formula of Abraham. If part of the mass is mechanical and part electrical, the rate of increase of the whole mass of the electron with increasing velocity will be somewhere between these two values.

If we substitute numerical values in the equation given above, it will be found that the difference between m and m_0 is quite inappreciable unless the speed of the particle is very high indeed. Thus when the velocity is as much as one-tenth that of

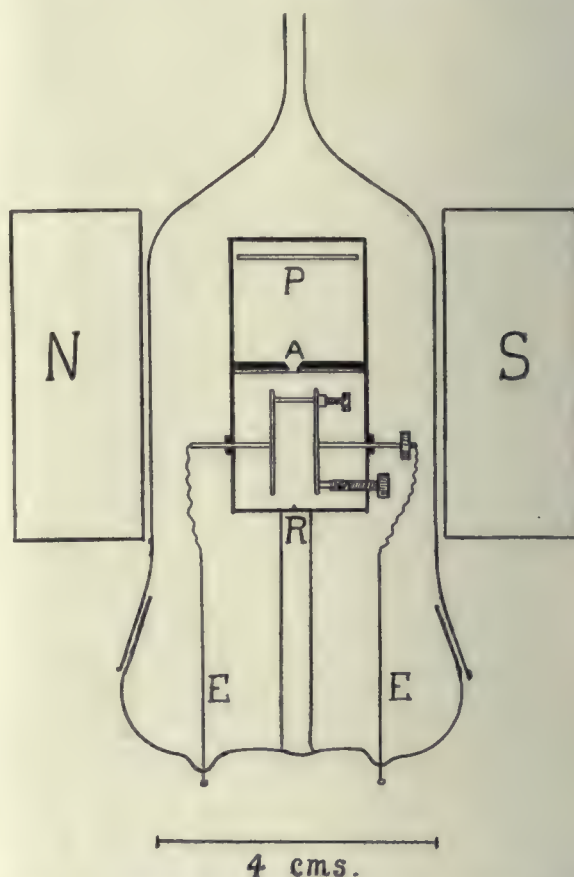


FIG. 18.—KAUFMANN'S APPARATUS FOR DETERMINING THE MASS OF A β PARTICLE.

light, the increase in the electrical mass only amounts to about 1%, while even when the velocity reaches one-third that of light, that is to say, over 60,000

miles per second, the increase in the mass is only about 5%. As this is the maximum velocity attainable in a discharge tube it might have been thought that the experimental investigation of the variation of mass with speed lay forever beyond our reach.

Fortunately this is not the case. Experiments have shown that the particles from radium, while otherwise similar to cathode rays, travel with velocities enormously greater even than those of the particles in a discharge tube, in some cases approaching within 4% of the velocity of light itself. For speeds such as this the electrical mass should be nearly three times its ordinary value, and thus, by careful experiments on these particles, we might well hope to put to the test the theories we have propounded.

Such experiments have been made with exquisite skill and care by Kaufmann. In principle the methods he employed were identical with those already described. The β -particles given out by a small quantity of radium placed at R (Fig. 18), passed through a fine hole in a lead screen at A, before finally falling on a photographic plate at P.

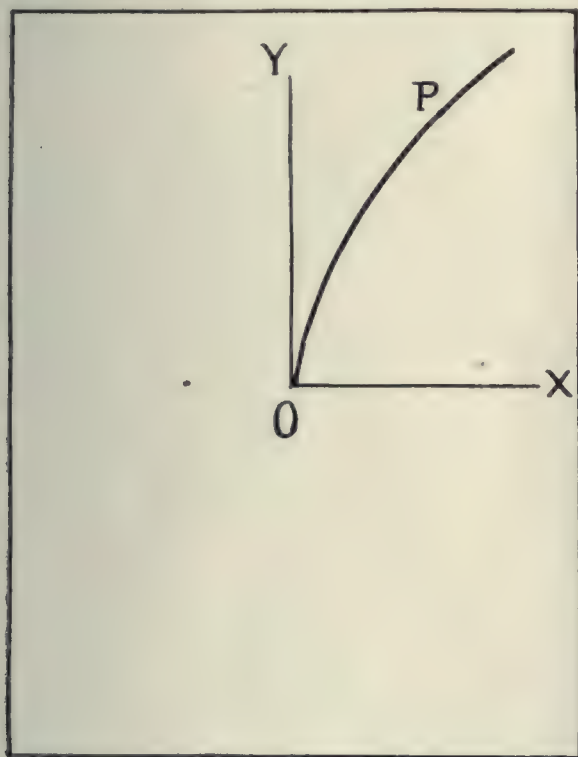


FIG. 19.—KAUFMANN'S EXPERIMENTAL CURVE FOR THE ELECTRIC MAGNETIC DEFLEXION OF THE β RAYS FROM RADIUM.

Before reaching the hole at A the particles passed between two parallel plates, which could be very carefully adjusted by means of a series of levelling screws, and which were charged to a high difference of potential. The whole of the apparatus was placed between the poles of a strong electromagnet N, S, arranged so that the electric and magnetic fields were parallel to each other and therefore the corresponding deflections they produced at right angles to each

other, exactly as in Professor Sir J. J. Thomson's experiments on the positive rays. Apart from the differences in velocity all the β -particles are identical. Thus, for every value of the velocity v there is only one corresponding value for the mass m . Hence the beam of rays is drawn out on the plate into a single curve (Fig. 19), every point on which corresponds to particles with a particular mass and speed.

This curve can be measured up with a micrometer in exactly the same way as has been described for the positive ray curves, and the mass and speed of the particles deduced by equations (c) and (d) (Chapter IV.). The values of the constants k_1 and k_2 for the apparatus were very accurately determined, as were also the strengths of the electric and magnetic fields. In this way Kaufmann obtained results which he regarded as being accurate to within 1.5%, a very notable achievement.

Some of the results obtained are given in Table V. The first column of the table gives the velocity of the particles, the second the value of β in Abraham's formula, that is to say, the ratio of the velocity of the particle to the velocity of light. In the third column we have Kaufmann's experimental values for the ratio of the whole mass of the particles to their mass at small velocities. The last column gives the theoretical value of this ratio, deduced from Abraham's equation, on the assumption that the whole of the mass is electrical.

TABLE V.

Kaufmann's values for the variation of the mass of a β -particle with change of velocity.

Velocity of the β -particle.	$\beta = \frac{\text{velocity of particle}}{\text{velocity of light.}}$	Experimental value of m/m_0 for the β -particle.	m/m_0 for Abraham's equation.
2.88×10^{10} cm. per sec.	.963	2.70	2.52
2.85 " "	.949	2.35	2.24
2.80 " "	.933	2.09	2.14
2.65 " "	.883	1.96	1.81
2.49 " "	.830	1.70	1.61
2.41 " "	.801	1.61	1.54
2.20 " "	.732	1.41	1.41

It will be seen how very closely, all things considered, the two sets of figures agree. The experimental values for the ratio m/m_0 increase, if anything, even more rapidly than theoretical. This would imply that, if anything, the mechanical mass of the electron is negative, which is, of course, an impossibility. The small discrepancy between the two sets of figures is no doubt due to a lack of knowledge as to the exact nature of the distribution of the electronic charge.

We have now discussed the evidence for our original statement that the whole mass of the electron is electrical in origin and due entirely to the charge it carries. Granting this conclusion, we can at once determine the dimensions of the electron, and so complete our knowledge of its properties. (To be continued.)

CHEMICAL ENGINEERING.

THE DEVELOPMENT OF THE WORLD'S COPPER MINING INDUSTRY IN THE YEARS 1898—1912.

By JOHN B. C. KERSHAW, F.I.C., F.S.S.

INTRODUCTION.

THERE is probably no other industry that can show such a remarkably rapid rate of expansion during the past quarter of a century as that of copper mining, for, taking the average price of the metal produced during this period as £60 per ton, the aggregate annual value of the output of copper by all the mines of the world has increased from £15,480,000 in 1898, to £60,024,000 in 1912, or by nearly 400%. In fact, if the aggregate value of the

metal produced, and, since the chemical engineer plays an important rôle in both the smelting and refining of the red metal, the following statistics recording the growth of the industry in the past fifteen years ought to prove of interest to readers of this journal.

It is quite true that the contribution of the mines of the United Kingdom to the total output of the metal is now small and insignificant, although the Cornish copper mines once occupied a most important place in the world's mining industry. In 1912 the total output of the English mines was, in fact, estimated to amount to only 400 tons. A large quantity of imported ore and raw copper, however, is still smelted and refined in this country, and the output of copper by the British colonies and by our overseas possessions is increasing. Canada, Australasia and South Africa are rapidly coming to the front as copper-producing countries, and in 1912 these three

WORLD'S TOTAL OUTPUT OF COPPER.

TONS.

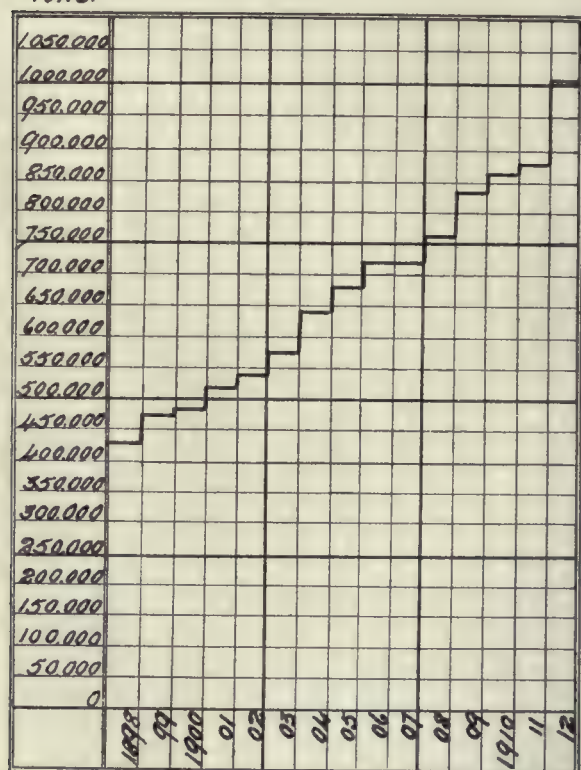


FIG. 1.

copper produced in 1912 be calculated on the basis of the average price obtained for bar copper in that year (namely, £73 per ton), the astonishing total of £73,290,000 is obtained as the present value of the annual output of the copper mining industry. These totals prove that the industry is only second to that of gold mining, in the value and importance of the

TABLE I.—TOTAL WORLD'S OUTPUT OF COPPER, 1898—1912.

Year.	Output in tons.	Increase or Decrease.
1898	429,626	29,896
1899	472,244	42,618
1900	479,514	7,270
1901	516,628	37,114
1902	541,295	24,667
1903	574,775	33,480
1904	644,000	69,225
1905	682,125	38,125
1906	714,100	31,975
1907	713,965	-135
1908	754,180	40,215
1909	839,425	85,245
1910	864,275	24,850
1911	871,920	7,645
1912	1,004,485	132,565

outlying portions of the British Empire produced in the aggregate 98,000 tons of copper, or nearly 10% of the world's total output. Through the developments occurring in its colonies, therefore, the old country is still maintaining its place in the ranks of the world's copper-producing countries, and there are many who believe that the mines of Rhodesia and of the territories north of the Zambesi alone will in time, contribute largely to the copper requirements of the world, and prove rivals of the great producing mines of the western States of America.

The figures used in preparing the tables and diagrams which illustrate this article are taken from

the valuable monthly and yearly statistical circulars prepared by Messrs. H. R. Merton & Co., of London, to whom the writer's thanks are due for permitting their carefully compiled returns to be used in this way.

I.—AGGREGATE PRODUCTION OF COPPER BY ALL THE COUNTRIES OF THE WORLD IN THE PERIOD 1898—1912.

Table I. and Diagram 1 give the statistics showing the rapid growth of the world's copper mining industry in the fifteen years ending in 1912.

*RELATIVE PRODUCTION BY U.S.A. (UPPER LINE)
AND OTHER COUNTRIES (LOWER LINE)*

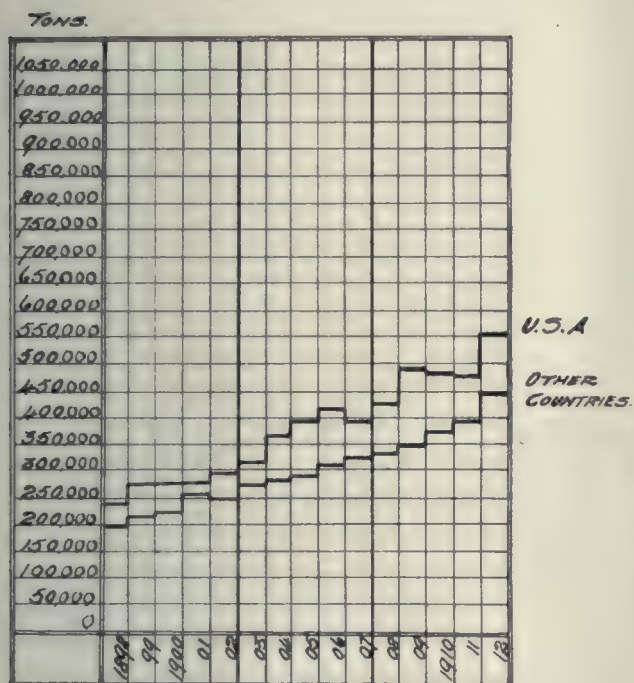


FIG. 2.

The variations in output from year to year are seen to have been very irregular, ranging from the enormous increase of 132,565 tons for the year 1912, to a decrease of 135 tons in 1907. The increase for the whole period is, however, very striking, for the output of copper has more than doubled in the period under review, and the rate of increase, if averaged over the fifteen years, gives an annual rate of increase of 40,000 tons, or 5.5%. Ten years ago an output of 1,000,000 tons of copper in one year would have been regarded as incredible, but the 1,000,000-ton mark has now been exceeded, and the demand for the red metal still grows, if present prices can be accepted as any criterion of demand.

II.—THE RELATIONSHIP BETWEEN THE WORLD'S TOTAL OUTPUT OF COPPER AND THE PRODUCTION OF THE U.S.A. MINES.

Table II. and Diagram 2 illustrate the relationship between the American copper production and

that of the remaining countries of the world, and are useful as showing clearly the predominating position occupied by the U.S.A. mines and copper mining financiers. The output of these mines in 1912 amounted to 554,835 tons, and the percentage of the total output provided from this source worked out to 55.4%. This figure agrees closely with 55.5% in 1911, and proves that, in spite of the large aggregate increase in production during the past year, the position occupied for so many years by the U.S.A. mines is still maintained.

TABLE II.—RELATIVE PRODUCTION OF COPPER BY THE MINES OF THE UNITED STATES AND THOSE OF OTHER COUNTRIES, 1898—1912.

Year.	U.S.A. Mines.		Other Countries.	
	Tons.	Percentage.	Tons.	Percentage.
1898	234,271	54	195,355	46
1899	262,206	55	210,038	45
1900	263,502	55	216,012	45
1901	265,250	51	251,378	49
1902	292,870	54	248,425	46
1903	307,570	53	267,205	47
1904	365,050	56	278,950	44
1905	389,120	57	293,005	45
1906	409,650	57	304,450	43
1907	392,520	55	321,445	45
1908	423,300	56	330,880	44
1909	490,280	57	349,145	43
1910	484,935	56	370,750	44
1911	483,865	55	388,064	45
1912	554,835	55	449,650	45

This position is clearly indicated in Diagram 2, and it can be seen that the margin between the aggregate output of the U.S.A. mines and that of all other countries is widening instead of diminishing. This paramount position of the U.S.A. mines in the copper mining industry undoubtedly enables the American copper financiers to exercise a control over the supplies of the metal, and to regulate prices in a manner that is unpleasant for the consumer but is outside the scope of this article to discuss.

III.—THE COPPER OUTPUT OF THE TWELVE MORE IMPORTANT REMAINING COUNTRIES IN THE PERIOD 1898—1912.

Tables III. and IV. and Diagrams 3 and 4 give the production figures from Messrs. H. R. Merton's returns, for the twelve more important remaining countries, for the fifteen years ending 1912. Although these twelve countries have greatly increased their aggregate output of the metal during the period under review, their proportion of the total output has remained stationary at slightly under 45%.

These twelve leading countries rank in the following order of importance as copper-producing countries, when judged by their output of the metal in 1912: Mexico, Japan, Spain and Portugal, Australasia, Chili, Canada, Russia, Peru, Germany, Africa, Norway, Servia. The figures for many of

these countries exhibit the striking progress of the copper mining industry during the period under review—Japan, Mexico, Russia, Australasia, Canada and Peru showing extraordinary developments of this industry.

Mexico, which in 1898 produced only 16,435 tons of the red metal, in 1912 produced 70,845 tons, and has permanently displaced the Spanish peninsula from its place of importance as a copper-producing country. The Mexican mines are controlled chiefly

Relative Copper Productions of Six
Leading Countries Excluding U.S.A.

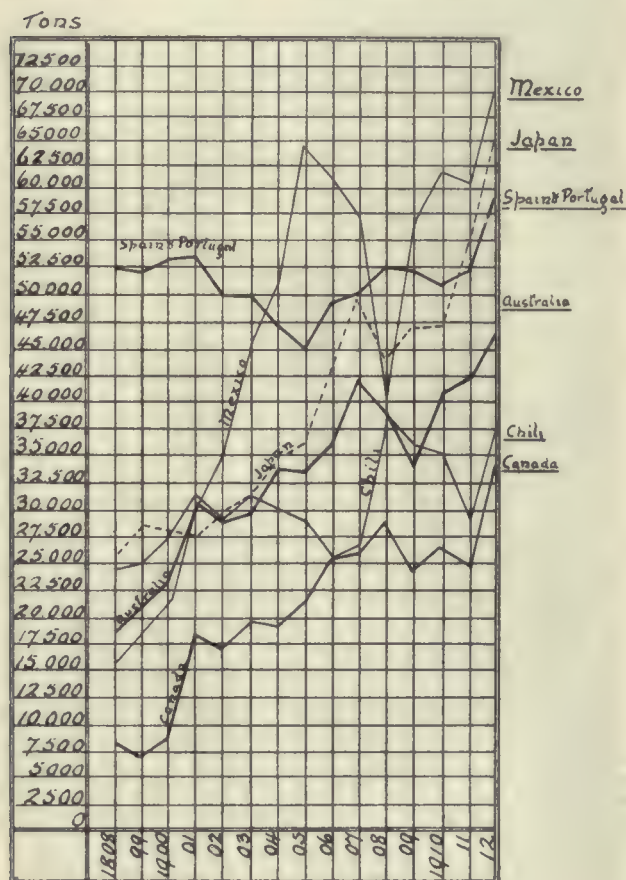


FIG. 3.

by American financial interests, and the output varies considerably according to the state of the copper market. In recent years a large number of old mines have been reopened and worked again, but these are closed down when the price of copper falls below a remunerative level.

Japan has shown steady progress as a copper-producing country during the past fifteen years, and has increased its output from 25,175 tons in 1898 to 65,500 tons in 1912, thus ranking third in the list of producing countries.

Australasia and Canada.—The copper mining and smelting industries in these two countries have also shown notable expansion in the period covered by the table—the Australasian output having

increased from 18,000 tons in 1898 to 47,020 tons in 1912; and the Canadian figures showing an increase from 8,040 tons to 34,710 tons.

Russia is another country in which the copper mining industry has experienced great developments in recent years, the figures in Table IV. showing an advance in production from 6,260 tons in 1898 to 33,010 tons in 1912.

Peru, however, is the country which can show the most remarkable expansion of the industry during the past fifteen years, the increase in this case being from 3,040 tons in 1898 to 27,165 tons in 1912. The output of copper has, however, remained stationary since 1910, and the inference is that the mines of Peru have about reached the upper limit of their productive capacity. Otherwise the great rise in the price of copper that occurred during the years 1911–1912 should certainly have brought about an increased output in the latter year.

Chili, which so long ago as 1879 produced nearly 50,000 tons of copper, is once again increasing her production, and has advanced from 24,850 tons to 37,305 tons in the period covered by Table III.

TABLE III.—THE COPPER OUTPUT OF THE LEADING PRODUCING COUNTRIES (EXCLUDING UNITED STATES OF AMERICA) FOR THE PERIOD 1898–1912.

Year.	Mexico.	Japan.	Spain and Portugal.	Australasia.	Chili.	Canada.
1898	16,435	25,175	52,375	18,000	24,850	8,040
1899	19,335	28,310	52,168	20,750	25,000	6,730
1900	22,050	27,840	52,872	23,020	25,700	8,500
1901	30,430	27,475	53,621	30,875	30,780	18,800
1902	35,785	29,775	49,790	28,640	28,930	17,485
1903	45,315	31,360	49,790	29,000	30,930	19,320
1904	50,945	34,850	47,035	34,160	30,100	19,185
1905	64,440	35,910	44,810	33,940	29,165	20,535
1906	60,625	42,740	49,320	36,250	25,745	25,460
1907	56,565	48,935	49,075	41,250	26,685	25,615
1908	39,990	43,000	52,585	39,500	38,315	28,570
1909	56,325	47,000	52,185	34,400	35,785	24,105
1910	61,515	46,000	50,255	40,315	35,235	25,715
1911	60,905	55,000	50,930	41,840	29,595	24,930
1912	70,845	65,500	58,930	47,020	37,305	34,710

Africa has advanced her output from 7,110 tons in 1898 to 16,370 tons in 1912, and, as already stated in the introduction to this article, when the ores from the much talked-of Tanjanyka mines are being smelted on a large scale, a notable addition to the copper exports of Africa may be expected. At present the smelters erected in the Zambesi district are not working satisfactorily, the restricted fuel supply having created greater difficulties than was anticipated.

Servia is a new addition to the ranks of the producing countries, and although the Servian mines only commenced to produce copper in 1908, their output in 1912 amounted to 7,240 tons.

The old-established copper mining industry in Spain and Portugal and in Germany does not show any figures for its expansion similar to those given above, the aim of those governing the production of the mines situated in these countries being to main-

tain a steady output, rather than to force production and exhaust the ore reserves, during the successive short periods of high prices.

Diagrams 3 and 4 show clearly the rapid expansion of the copper mining industry in ten out of the twelve countries dealt with in the diagrams during the period 1898—1912, and summarise in graphic form the information as to progress given above.

Relative Copper Production of Six Minor Countries

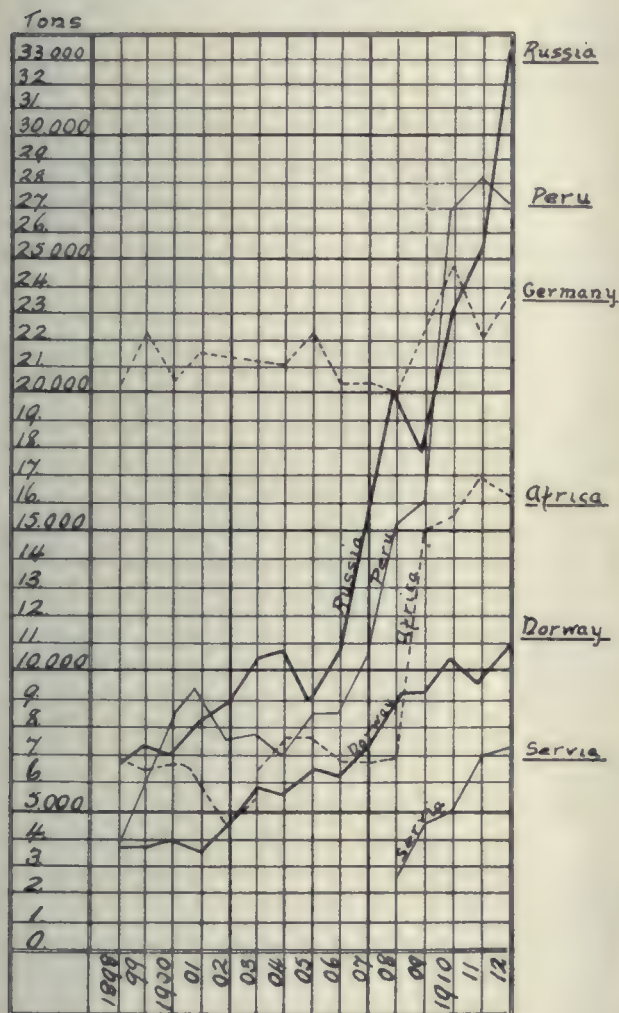


FIG. 4.

IV.—VARIATIONS IN VALUE FOR THE PERIOD 1898—1912, AND THE RELATIONSHIP BETWEEN OUTPUT AND PRICE.

The figures showing the average price of standard bar copper are given in Table V., which also contains the figures for the world's total output of copper in each of the years named. Diagram 5 gives these figures in graphic form, and it will be noticed that the "curve" for the price variations shows three periods of high prices with three depressions. The price boom of 1898—1899 was due to the formation of the Amalgamated Copper Company in the States ;

the second and third booms have been due to more natural causes, namely, the extremely active state of trade in the shipbuilding and electrical engineering and allied industries, at a period when there was some slackening-off in the rate of production in the copper mining industry, and, in consequence, some depletion of stocks.

As pointed out by a writer in *The Times* recently, activity in the shipbuilding industry creates a great demand for copper, and

"if the man-in-the-street or the speculator in copper-warrants were to make an exhaustive examination of a first-class, high-speed ocean liner, he would be amazed at the quantity of copper, plain or as brass, required about her engines, her auxiliary plant, her sanitary arrangements, her kitchens, her saloons, state-rooms, and staircases, even her port-holes, rails and scuppers."

TABLE IV.—THE COPPER OUTPUT OF THE MINOR PRODUCING COUNTRIES (EXCLUDING UNITED STATES OF AMERICA) FOR THE PERIOD 1898—1912.

Year.	Russia.	Peru.	Germany	Africa.	Norway.	Servia.
1898	6,260	3,040	20,085	7,110	3,616	
1899	7,210	5,165	23,460	6,490	3,610	
1900	6,740	8,220	20,410	6,720	3,935	
1901	8,000	9,520	21,720	6,400	3,375	
1902	8,675	7,580	21,605	4,450	4,565	
1903	10,320	7,800	21,205	5,230	5,915	
1904	10,700	8,755	21,045	7,775	5,415	
1905	8,700	8,625	22,160	7,740	6,305	
1906	10,490	8,505	20,340	6,980	6,120	
1907	15,000	10,575	20,490	6,800	7,010	
1908	20,085	15,000	20,200	6,880	9,190	2,140
1909	17,750	16,000	22,455	14,945	9,080	4,480
1910	22,310	26,945	24,710	15,205	10,425	4,845
1911	25,310	28,050	22,010	16,980	9,420	6,885
1912	33,010	27,165	23,920	16,370	10,980	7,240

The estimated consumption of copper in 1912 was 1,024,000 tons, for the stocks were reduced by 20,000 tons between January and December 31st in

TABLE V.—THE WORLD'S OUTPUT OF COPPER COMPARED WITH THE AVERAGE PRICE OF "STANDARD" METAL, FOR THE PERIOD 1898—1912.

Year.	Total Output.	Average Price per ton.
		£ s. d.
1898	 429,626	51 7 10
1899	 472,244	72 10 6
1900	 479,514	73 19 7
1901	 516,628	67 17 3
1902	 541,295	52 13 5
1903	 574,775	57 18 8
1904	 644,000	58 14 8
1905	 682,125	69 2 6
1906	 714,100	86 5 2
1907	 713,965	87 1 8
1908	 754,180	60 0 6
1909	 839,425	58 17 3
1910	 864,275	57 3 2
1911	 871,920	55 16 2
1912	 1,004,485	73 1 3

that year, and the output amounted, as already stated, to the huge total of 1,004,000 tons. How long the mines of the world can continue to supply copper at this rate is a question, the answer to which

*The World's Annual Output of Copper &
Average Price for Period 1898-1912.*

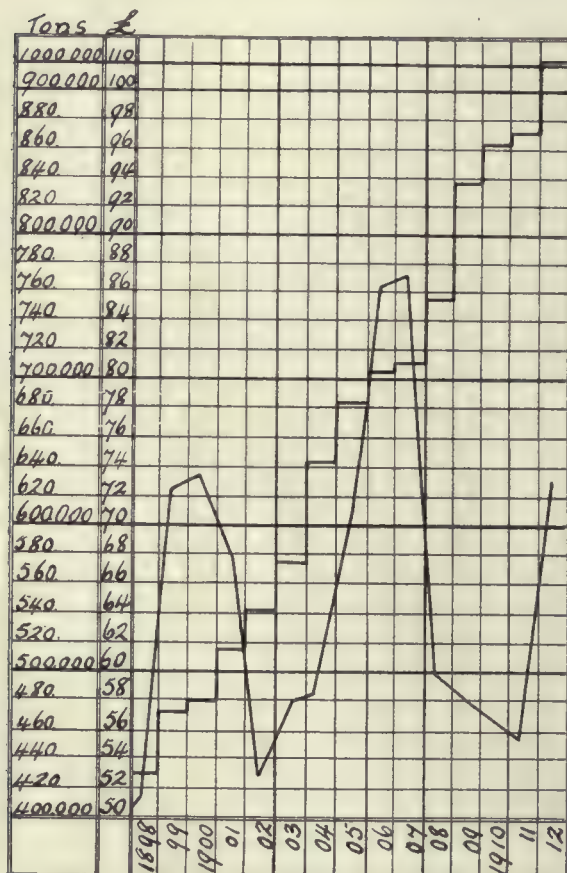


FIG. 5.

only the future can disclose, but there will undoubtedly come a time when the supplies of ore of the red metal will become exhausted and when copper will appreciate enormously in value owing to this cause. It will then be the duty of the chemist and metallurgist to provide a satisfactory substitute for the metal which has so long occupied a foremost place in the metal industry of the world, and it will no doubt be found that aluminium, or some of the aluminium alloys, can be used for many of the hundred-and-one purposes for which copper is now universally employed.

Graphite Industry.—It is stated on the authority of the Chief of the Mining Department of Madagascar that the graphite industry in the island is making considerable progress, the quantity exported during the first quarter of this year amounting to 980 kilos. as compared with 474 kilos. during the corresponding period of last year, and 259 kilos. for the corresponding period in 1911. It is believed that by 1916 the quantity exported will reach 20 metric tons annually.—*Board of Trade Journal.*

FINANCIAL NOTES.

The report of the Lankat Rubber Company shows a credit balance of £31,099, with the addition of £4,463 brought forward from last year, a total of £35,562 is available. An interim dividend of 7½% has been paid, £5,000 has been placed to reserve, and £805 allocated to meet the extra remuneration payable to the directors, leaving a balance of £22,257. The directors propose to pay a final dividend of 15% for the year ended March 31st, making a total distribution of 22½%, carrying forward £7,257.

The Niddrie and Benhar Coal Company's total profits for the year ended April 30th amount to £37,460. A dividend of 10% is recommended, leaving £3,541 to be carried forward.

After providing for debenture interest, depreciation, etc., the accounts of Messrs. James Keith and Blackman Co., Ltd., show a net profit of £22,624, and this sum, with the balance brought forward, makes a total of £25,056. A dividend on the Ordinary shares at the rate of 10% per annum absorbs £6,801, the sum of £9,000 is transferred to reserve account, and £3,550 is carried forward.

At the annual meeting of the Minerals Separation (American) Syndicate, Ltd., the Chairman said that the two years and seven months since the formation of the Company had been spent in exploration work, during which the possibilities of their process had been emphasised. One mine had treated 2,852,515 tons of ore during 1912, assaying 1·6% copper for a recovery of 68·25%. This yielded a total of 65,881,116 lbs. of copper. In the tests by minerals separation process the same ore yielded a recovery of 85%; or at the rate of 82,049,741 lbs. of copper from the same tonnage treated, which, with copper at 14 c., would have yielded an additional income of \$933,639, after deducting royalty, etc.; by their process they produced a grade of 16% copper against 10·49% by the mining company, so that the actual figures in their favour after deducting royalties, etc., would have amounted to a sum of \$1,795,161.

At the recent meeting of the Malacca Rubber Plantations, Ltd., the Chairman announced that they had spent upon the estates during the year under review the sum of £124,000, against the sum of £208,000 during 1911. Further large reductions were expected during the next year. The output was 2,219,990 lbs., against 1,086,000 for 1911, the average selling price working out at 4s. 6½d. per lb. The Chairman suggested improvements in the present methods of selling rubber by means of periodical options without reserve, and called for the co-operation of rubber companies.

The gross trading profit made by the Mouldham Cement Company for the past year amounts to £35,427, and the available profit £19,993. A dividend of 6% on the Preference shares is recommended, leaving a balance of £6,482.

The net profits earned by Kynoch, Ltd., during the past year amount to £126,267. A dividend of 2½% is proposed, £40,000 being written off, and a substantial sum carried forward.

NOTES ON CHEMICAL ENGINEERING.

By J. W. HINCHLEY, A.R.S.M., WH.Sc.

CHAPTER II.—(continued).

SIFTING.

WOVEN wire for screening purposes is produced by means of a loom similar to that used for cloth weaving. A series of wires are arranged at a uniform pitch to form the "warp," and the wire forming the "weft" or "shoot," passes above and below each wire of the warp alternately. In the loom, alternate wires of the warp are raised and depressed to allow the weft to be shot between and driven home by a comb or reed, and the operation repeated by raising the set of alternate wires which were depressed before, and so on. The kinking of the wire produced in these operations preserves the size and shape of the meshes, unless the wire be very thin.

It is obvious that the open space between the wires of the warp must be greater than the diameter of the weft wire, and that the diameter of the latter determines the finest limit of size of opening possible in this method of straight weaving. By using fine wire for the weft, and stout wire for the warp, com-

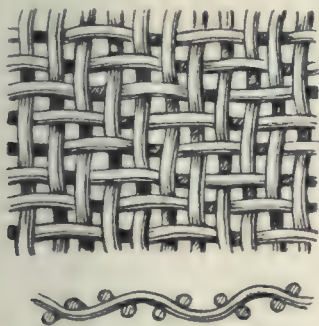


FIG. 34.

paratively fine screens can be made, but the practical limit of fineness is reached at 120 meshes to the linear inch.

Finer screening surfaces of wire are desirable, and these are always produced by a variation of the weaving process called "twilling," in which sets of two or more wires of the warp are raised, and one or more wires depressed before passing the weft (Fig. 34). In this way, a more or less diagonal pattern is produced on the surface of the material.

Such twilled wire cloth is not well adapted for sifting, on account of the irregularity of the openings and its consequent tendency to choke.

In all wire-woven screens, exact truth of mesh is rarely obtained, the pitch of the weft wires is usually greater than that of the warp and somewhat irregular, owing to the character of the knocking-up process.

Silk gauze is produced in a different way on account of the fact that some device is necessary to preserve the meshes. In coarse meshes, two warp

threads are used in place of one, and after the passage of the weft are twisted together. In finer meshes, single warped threads are introduced between the double threads, a sufficient number of double threads being used to effectively preserve the mesh (Fig. 35).

In very fine wire open mesh cloth, the mesh may be preserved by passing two weft wires close together; the openings in this case are usually oblong.

There is a type of sifting surface which has recently come into great favour, which is formed by stretching a series of piano wires across a frame. It is, in fact, the warp of a woven wire screen without the weft. The wires are tightened up by keys, and are readily replaced when worn out; by the use of different pitch combs the fineness of the screen may be modified to meet altered conditions. The wear of such screens is less than that of woven wire screens, not only on account of the hardness of the wire, but also because each wire gives way bodily to blows from the material. The opening factor of such screens is very large, and choking is practically absent.

By using very stout wires, flat and cylindrical screens are made which are adjustable in pitch. They present no advantage to the chemical industry for their increased cost, but in grain screening their use is extensive.

If a quantity of particles not too large to pass through its meshes be placed on a stationary horizontal screen, only a very small quantity will pass through before sifting ceases. Agitation, however, makes the sifting continuous, until all the particles have passed through the sieve. The failure of the stationary sieve is, of course, due to arching of the material taking place at each opening, while the agitation breaks down the arch structure; but in addition to this, the agitation has another effect. It will be noticed if the material in the sieve be watched, that the coarse material rises to the surface, and is the last to pass through. The higher bulk specific gravity of the fine material, together with its wedging effect, displaces the coarse material, and after a time the material on the sieve has separated into layers of different fineness. The finest material will thus pass through first, to be followed by coarser material, until that just small enough passes through with difficulty and probably some choking. The best sifting arrangements avoid this action of particles just small enough to pass through with the accompanying choking, excessive wear and small output.

If grading in size is to be carried out, it is better to remove the larger particles first, and the small particles last, relieving the fine screens from the weight, wear, and choking which results from the reverse procedure.

Where only the fine material is required, and the

oversize is returned for further grinding, sifting plant in which separation into layers takes place by preliminary vibration is most satisfactory if economical work is to be effected. Knowing the percentage of fine material present, the length of screen surface necessary can be determined, and in the case of several sizes relatively estimated.

Each movement of a sifting surface may produce a separating and a sifting effect, and it is convenient to consider the smallest movement which will deter-

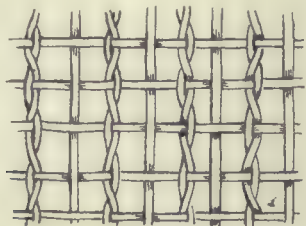


FIG. 35.

mine the sifting of the lowest layer of particles as a "sifting action." The size of the particles and the opening factor will determine the number of sifting actions required for dealing with a given depth of material; or the number of particles just small enough to pass through the screen and capable of being contained in a given depth of material, divided by the number that will pass through at each sifting action, will give the number of sifting actions necessary to sift that depth of material.

What constitutes a sifting action in any sifting machine is determined by the relative movement of the material to the screening surface and sometimes by the pitch of the openings in the screen.

In vibrating screens, where the material is lifted at each vibration, the number of sifting actions is equal to, or a multiple of, the number of vibrations occurring, in the same time. In screens where the material slides over the surface the number of sifting actions will be a function of the relative velocity of the material and the pitch of the sifting surface. In piano wire screens the action is continuous, and determined by frictional conditions of the material with regard to itself and the wire surface.

TYPICAL WOVEN WIRE.

Mesh.	Pitch.	Diam. of wire.	Diam. of hole.	Opening factor.	Number of sifting actions per inch of depth.
4	.250	.0360	.214	.855	9
5	.200	.0320	.168	.84	12
5	.200	.0800	.120	.60	33
8	.125	.0220	.103	.824	20
10	.100	.0200	.080	.80	28
10	.100	.0480	.052	.52	100
20	.050	.0142	.0358	.716	78
50	.020	.0084	.0116	.58	366
150	.0066	.0028	.0038	.576	1,154
200	.0050	.0020	.0030	.60	1,319

There are obviously limits of speed above and below which the rate of moving or vibrating would

have no corresponding effect on the sifting operation. These limits are best determined experimentally, since they depend on many influences, the material, the screens, the production of air currents, etc.

Provided that the material does not cake or clog, it is possible to estimate with sufficient accuracy by these considerations the effect of changes in the methods of working plant, or in the character of the sizing, and, with the help of a small scale test to closely estimate outputs.

Fine screening is much more difficult than coarse work, and on account of choking, demands generous estimating.

The effective area for sifting depends largely on the feeding arrangements, and varies with the fineness of mesh. For flat screens working nearly horizontally, a vibrating tray is much the best method of delivering a uniform feed, and in addition, acts as a preliminary separator. The worm conveyor delivering through a slit is also used, especially for inclined screens. Five or six inches of screening surface at the sides of flat screens, and at the ends of cylindrical screens, are usually ineffective.

The height to which particles of material will rise in round screens, the effective screening area and the limit of speed can be readily determined if the angle of repose of the material on the screen is known.

In the figure (Fig. 36), f is the angle of friction of the material on the screen, *i.e.*, the inclination of the tangent at the point where the particles slide, with the horizontal when the screen is at rest; i is the increase of this angle due to the rotation of the screen, so that, $(f + i)$ will be the inclination of the tangent at the highest point A reached by the material, to the horizontal when the screen is in motion; r and v are

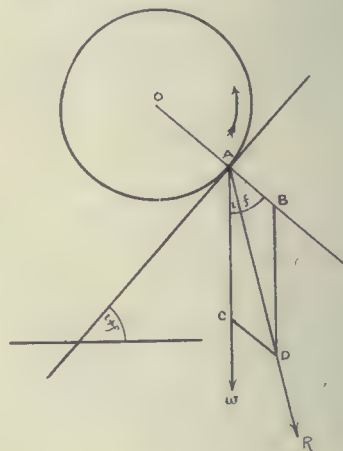


FIG. 36.

the radius of the screen (in feet) and the velocity of its surface (in feet per second). If AC represents the weight of the particle, and AB its centrifugal force, and since each of these lines is at right angles to the horizontal, and the tangent at A respectively, the angle CAB = $(f + i)$, the angle CAD = i , and the angle DAB = f ; also the angle CDA = f

$$\frac{\sin i}{\sin f} = \frac{wv^2}{gr} \div w$$

where w = weight of the particle,

$$i.e., \sin i = \sin f \frac{v^2}{gr}$$

If the value of i exceed 90° , it is obvious that the particle cannot fall, *i.e.*, the limit of speed is given when

$$\sin f \frac{v^2}{gr} = 1.$$

If f be taken as 35° , a common value, and the formula be modified to give N the number of revolutions per minute, then the limit of speed is given by the formula

$$N = \sqrt{\frac{5119}{r}}.$$

Knowing the angle at which the ore slides ($i + f$) and the inclination of the screen j , the pitch angle p at which the material will slide with reference to the screen (describing a helix on the screen surface) can be readily seen to be given by

$$\sin p = \frac{\sin j}{\sin (i + f)}$$

and the distance l moved along the screen during one revolution will be

$$l = 2\pi r \tan p.$$

Or, if L be the length of the cylindrical screen, the number of revolutions n required for the travel of the material through the screen will be

$$n = \frac{L}{2\pi r \tan p}.$$

Since by altering the angle of inclination j of the screen an increase of feed can be given without altering the depth of material, an adjustment for the inclination of the screen provides a simple method of obtaining the maximum output for a given material.

(To be continued.)

ENGINEERING NOTES.

By R. J. DUNDERDALE, B.A. (CAMB.), A.M.I.C.E.

Naphthaline as a Coal Briquet Binder.

Efforts have been made from time to time to use this substance instead of pitch as a briquet binder, when the pitch market was up. The problem yielded no satisfactory results, until von Schüring made it practicable in the following way. The naphthaline is melted by superheated steam in a closed tank, and then vaporised by a steam jet delivered at a temperature of about 260°C ., which is well above the naphthaline vapour point. The vapour is blown upwards through a heated mass of coal dust and pitch (this last in a much reduced quantity), and rises through a reasonably thick layer of these materials. The Blankenburg mines have adopted this process, and it is said to reduce the cost of briquet manufacture by about 65 pf. a ton. This is a saving of about 27% on the previous cost of the process. The amount of naphthaline used is about 3% of the total lot, and markedly more than this is

found to make the mass adhere to the moulds and plungers. A short article giving full details of the process will be found in the Essen paper *Glückauf* for last year, p. 1536.

Mining Machinery at Islington. Coal Cutters.

Most of the exhibits at the Royal Agricultural Hall were of a purely mechanical nature, and one of the most purely mechanical among them was the coal cutter of various types, non-percussive and otherwise.

The interesting thing about the coal cutters generally is that a great many of them are fitted to drive electrically instead of by compressed air. This, in some respects, chiefly in having regard to safety, seems to be almost a retrograde movement.

If there is one place where compressed air as a drive appears to excel all others on general considerations, it is where (1) there is considerable warmth, and (2) where there is a danger of fire; and this applies to chemical factories as much as to coal mining. The first condition prevents the freezing of exhausts and the filling up of parts of the air motor with ice, and the second condition is fulfilled with compressed air in a way that it can never be by electrically driven machinery, where, however good the insulation, and careful the men, shorts are apt to occur from time to time and possibly with serious sparking just when such sparking may be of appalling risk.

Crotogino Tubes.

In *Engineering* for April 25th there is a short notice of these tubes, together with a couple of sections, longitudinal and transverse.

They should certainly be of interest to chemical engineers, as they offer a wood-lined tube with a casing of say, mild steel, which should make them reasonably strong and light. The makers assert that they can be bent slightly when lined, and that they can supply bends in this construction.

Where considerable heat is absent they should offer several obvious advantages over lead or tin lining, where lead or wood or tin linings are equally suitable chemically.

It would be interesting, however, to know the life of a pipe line constructed in this manner, and conveying a liquor capable of actively attacking iron.

Comparative Fuel Values of Gasoline and Denatured Alcohol in Internal Combustion Engines.

Under the above title (Bulletin 43 of the United States Bureau of Mines) Messrs. R. M. Strong and L. Stone give a very interesting and instructive account of comparative trials with the fuels mentioned.

About two thousand tests in all were made on several engines now belonging to the department of Mines, U.S.A.

Numerous tests of the two fuels used showed the average composition of the gasoline to approximate to a hydrocarbon having the formula of Hexane C_6H_{14} , and of the alcohol to ethyl alcohol (very roughly) $\text{C}_2\text{H}_5\text{O}$. But, of course, it is not to be gathered that the samples were chiefly composed of either definite constituent, but of the usual mixtures of many. On the showing of the report, a very good case can be made out for alcohol, on account of its higher flash point and higher thermal efficiency when actually in the cylinder owing to the much higher compression which can be obtained without danger of pre-ignition. A very good *résumé* of the report appears in *Engineering* for May 23rd.

REVIEWS OF BOOKS.

"ELECTROPLATING." By **W. R. Barclay and Cecil H. Hainsworth.** EDWARD ARNOLD, London, 1912. Pages 399 + v, including Index and Appendices. Chapters XIX., including 62 Illustrations. Price 7/6 net.

THIS book has been written as a handbook for the practical electro-plater, and bears evidence of having been written by those who have knowledge of working conditions.

The subject-matter follows much the usual course of such works, and briefly describes the many operations involved in the preparatory process, and the deposition of such metals as gold, copper, silver, iron, cobalt and zinc.

Perhaps the best chapter deals with the deposition of brass and other alloys, although interesting data is given in the chapter dealing with the deposition of nickel. The question of the influence of third substances on the deposition of copper is dealt with, and the work gives to the general student a good idea as to the many methods by which metals may be deposited in a technically satisfactory condition.

The first 146 pages deal in an elementary manner with primary and secondary cells, the dynamo, and fundamental chemical properties, so that the work forms in itself an instructive text-book on an important subject. If the general arrangement of subject-matter is questioned, it might be said that, under present-day conditions, the first 146 pages could have been omitted, which step would have allowed for a corresponding extension of detail in actual procedure.

"ALLEN'S COMMERCIAL ORGANIC ANALYSIS,"

Vol. VII. Alkaloids, Glucosides, Animal Bases, Animal Acids and Cyanides. Edited by **W. A. DAVIS** and **S. S. SADTLER.** Contributors: **W. A. Davis, E. Frankland Armstrong, G. C. Jones, A. E. Taylor, G. Barger, J. A. Mandel, and Herbert Philipp.** J. & A. CHURCHILL, London, 1913. Pages 563 + ix, including Index. Price 21/- net.

The seventh volume of this standard work of analysis is devoted to the vegetable alkaloids, non-glucosidal bitter principles, animal bases, animal acids, lactic acid and cyanogen derivatives. The section on vegetable alkaloids, by **Dr. Barger**, is very complete, and the same remark may be made about the section dealing with the glucosides, by **Dr. E. F. Armstrong.** The section by **G. C. Jones** on the non-glucosidal bitter principles contains an important and complete account of the bitters and resins of hops, aloes, colocynth bitter. Reference is made to certain Bills before Parliament to altogether prevent the use of hop substitutes.

The section on the amino acids and their isolation contains useful illustrations of the actual appearance of such amino acids as tyrosine, leucine, and the like. This section, with that on the animal acids by **Dr. Mandel**, is also quite satisfactory. One of the

editors, **Mr. W. A. Davis**, is responsible for the section dealing with lactic acid, and, in view of its increased use in many industries, is a valuable *résumé* of this subject. The final section is on cyanogen compounds. It is noticed that the recent method of estimating ferrocyanides by **Williams** is not included in the methods given, but, doubtless, the volume went to press too early for its inclusion.

Considering the mass of data included in this volume, very few errors can be detected, and all concerned may be satisfied with the result and the general usefulness of this volume.

"DAIRY TECHNOLOGY." By **C. Larsen and W. White.**

CHAPMAN & HALL, LTD., London, 1913. Pages 298 + xiii., including Index. Chapters XXXII., with 48 Illustrations. Price 6/6 net.

At a time when the question of milk supply is before the public in this country, this work on the technology of the dairy appears at an opportune moment. The work is divided into four parts and thirty-two chapters. The first four chapters deal respectively with milk as a food, city milk supply, ice-cream making, and by-products in the creamery and cheese factory.

It is well illustrated and well printed. The chapters on milk powder, fermented milks, casein, sanitary examination of milk, and importance of the milk supply, all contain subject-matter of general interest, especially with reference to conditions as they exist in America.

"DIE EXISTENZ DER MOLEKÜLE." By **The Svedberg.**

Akademische Verlagsgesellschaft m.b.H. Leipzig, 1912. Pages 243 + viii., including Index. Divided into 2 Parts and 4 Sections, including 76 Illustrations. Price M. 12.

This very important text-book deals with the consideration of certain phenomena connected with molecular physics. The work is divided into two main sections dealing with such subjects as colour-metric and spectroscopic measurement, diffusion, Brownian movement, and spontaneous concentration phenomena in radioactive solutions and gases.

The work is well illustrated by photographs of apparatus and by a series of curves and tables. It, of course, demands on the part of the reader a fair knowledge of mathematics. A satisfactory name and subject-matter index will be found at the end of the volume.

The author must be congratulated on the extreme care with which the subject-matter has been brought together and treated. This work should find a place in the library of all colleges, where advanced physical work is undertaken. It will be read with great interest in the ever-growing circle of those interested in the subject of molecular physics.

"A DICTIONARY OF APPLIED CHEMISTRY." Edited by Sir Edward Thorpe. Revised and Enlarged. LONGMANS, GREEN & Co., London, 1912. Vol. IV., OILSTONE—SODA NITRE. Pages 727 + viii. Numerous Illustrations. Price 45/- net.

The fourth volume of this dictionary is to hand, and, like its predecessors, may be said to be satisfactory in every respect. As this work nears completion it is possible to form some opinion as to its value, which is obviously of a very high order. Once more it is difficult to select articles for special praise, but those on petroleum, photography, polarimetry, potassium, pyrometry, quinones, and saponification, may be specially mentioned.

A series of references to this volume will at once indicate that the information given is of great value and of the right order. It only remains once more to congratulate the editor on its production, and to repeat that at last there is in the English language a dictionary which may be referred to with all confidence by the general chemist.

BOOKS RECEIVED.

"A Dictionary of Applied Chemistry," Edited by Sir Edward Thorpe. Revised and Enlarged. Longmans, Green & Co., London, 1912. Vol. IV. OILSTONE—SODA NITRE. Pages 727 + viii. Numerous Illustrations. Price 45/- net.

"Liquid Steel; Its Manufacture and Cost," by David Carnegie, assisted by Sidney C. Gladwyn. Longmans, Green & Co., London, 1913. Pages 520 + vi, including Index. Chapters XLVIII., with 10 Plates and 252 Illustrations. Price 25/- net.

"Treatise on General and Industrial Organic Chemistry," by Ettore Molinari. Translated by Thomas H. Pope. J. & A. Churchill, London, 1913. Pages 770 + viii., including Index. Divided into III. Parts, with 506 Illustrations. Price 24/- net.

"Annual Tables of Constants and Numerical Data, Chemical, Physical, and Technological." Subject-matter in French. Vol. II. Pages 758 + xi. J. & A. Churchill, London, 1913. Price 28/6 net cloth; 25/6 net paper.

"Organische Arsenverbindungen und ihre chemotherapeutische Bedeutung," by M. Nierenstein. Ferdinand Enke, Stuttgart, 1912. Pages 94. Price M.1.50

"Grundriss der Kristallographie," by Gottlob Linck. Third Edition. Gustav Fischer, Jena, 1913. Pages 272 + v., with Index. IV. Parts with 15 Chapters, including 631 Illustrations and 3 Tables. Price M.11.50.

"Tanners' Year Book, 1913." Edited by M. C. Lamb and J. Gordon Parker. The Technical Publishing Co., London. Pages 178, with numerous Illustrations and Tables. Price 3/-

"The Function and Scope of the Chemist in a Pharmaceutical Works," by Charles Alexander Hill. Published by the Institute of Chemistry, 1913. Pages 43, with 15 Illustrations. Price 2/- to non-members.

"Apparatus for the Exact Analysis of Flue Gas," by George A. Burrell, and Frank M. Seibert. Technical Paper 31, Bureau of Mines, Washington, U.S.A., 1913. Pages 12, with 1 Illustration.

"The Preparation of Specifications for Petroleum Products," by Irving C. Allen. Technical Paper 36, Bureau of Mines, Washington, U.S.A., 1913. Pages 12.

COMMERCIAL AND GENERAL NOTES.

New Chemical Process for Hardening Metals.

A Swiss firm at Zürich has recently introduced a new process for hardening metals. The iron and steel to be treated are placed into an iron receptacle, the bottom of which is covered to a depth of $\frac{1}{2}$ to 1 in. with a special charging preparation, called "Acietit." The case is then placed into the heating furnace. After the lapse of about three hours, and with a temperature of 800°, the charge will have penetrated the metal to a depth of $\frac{1}{2}$ in. If double the time is given, and the temperature kept at 1,000°, even the largest articles are converted into steel, leaving only a small core of the original composition. Chrome nickel steel obtains the hardness of glass at a temperature of 750°. The object treated in this way obtains a finely-grained texture, and the hardness is quite permanent. The new preparation is being used in several large Continental factories, and will soon be exported to England and the United States.

Interesting Letters from a German Scientist.

A German technical paper reports the discovery of some hitherto unpublished letters from the chemist Whöler to Berzelius. These were found amongst the papers of the late L. F. Svanberg. The letters, which were written in 1848, contain, in addition to a vivid description of those times of political unrest, a few interesting scientific data concerning the research work upon which Whöler was engaged at the time. One of these letters, dated March 8th, contains the following passage: "I will also send thee shortly a dissertation on so-called turpentine camphor, a truly beautiful work, which has been carried out in my laboratory by Herr List. In this investigation a really remarkable example of catalysis has been shown. When turpentine camphor, $C_{20}H_{21}O_4$, is warmed up with any acid, it is converted into a volatile oil, with a perfect aroma of hyacinths, which is $C_{20}H_{17}O$. It appears that one single drop of acid is capable of converting endless masses of camphor." The research referred to was published by Leit, in 1848, in "Liebig's Annalen." The turpentine oil camphor was, of course, terpine hydrate, and the hyacinth odour was obviously due to the presence of terpineol, which, of course, is really much more closely allied to lilac than to hyacinth in odour.

The German Chemical Exports during the First Quarter of 1913.

Although some apprehension had been aroused as regards the German exports of chemicals, which seemed likely to suffer under the influence of the Balkan war, the official returns prove this apprehension to have been unfounded. The total returns for the first quarter of the current year represent 12,855,924 double centners, to the value of 248,136,000 marks, this showing an increase of 1,875,546 double centners, of a value of 51,080,000 marks, compared with the corresponding period of last year. Almost every section contributes to this increase. The most striking feature is the total exports of chemical compounds, acids, salt, etc., amounting to 9,677,135 double centners—

an increase of about 1,855,000 double centners against last year. Paints and colours also account for a large increase, while explosives, etc., have increased by about 6,500 double centners. On the other hand, there has been a notable falling off under the heading of fertilisers.

Rock Salt Discovery in British Columbia.

The discovery of rock salt in large quantities in British Columbia is reported. It has been known for some time that a deposit of salt existed at this place, and prospecting has been carried on, with the result that a solid salt bed was struck by the drilling party. So far five holes have been drilled, in some instances over a mile apart, and in every case salt has been struck at depths varying from 50 to 250 ft. The discoverers have erected a small testing plant on the property, and the tests show that the product is absolutely pure salt of the best quality.

Wood Preservatives in Canada.

The preserving of timber by the use of chemical agents is extending in Canada as a branch of the wood-working business. Zinc chloride is now being used for the purpose. The wood to be treated is placed on small bogie trucks, which are then pulled into long steel cylinders. The doors are closed, and the air in the cylinders is exhausted until a vacuum of about 26° is obtained. A solution of zinc chloride, to which a proportion of sulphate of alumina has been added, is then run into the cylinder at a temperature of about 140° F. The pressure is increased until it reaches about 130 lbs. per square inch. The temperature is then raised to about 150° F., and is maintained at that degree for about an hour. The preserving process is now complete. The zinc chloride process has been adopted at some large new timber-preserving works in Ontario, the erection of which were begun about a year ago. The addition of the sulphate of alumina to zinc chloride solution entirely prevents, it is said, the loss of chloride from the wood, which would otherwise occur in a short time. The preserving of wood by the use of creosote is, however, still carried on to a great extent.

A Soap Factory for Saskatchewan.

It is now definitely assured that a soap factory will be among the industries to locate in Weyburn (Saskatchewan) this year. The vice-president of the Detroit Chemical Laboratories, Mr. Lamont, after a thorough investigation of the manufacturing and distributing possibilities of this point, and an analysis of the water supplied by the town, has written to the Board of Trade informing that body that he will arrive in Weyburn shortly for the purpose of beginning operations.

Chemical Fertilisers in Italy.

According to a French Government report, the use of artificial manures is increasing in Italy every year. The old-fashioned practice of cultivating the soil is giving place to modern methods, based on scientific research and a careful study of the requirements of the soil. The use of artificial manure is of comparatively recent date, for previous to 1880 it was but little known, and its high price prevented the farmers from experimenting liberally or even testing it properly. At the present time the price of most artificial manures is moderate enough to enable even small farmers to enrich their soil by their use. Italy possesses no less than 118 manufactories of chemical fertilisers, with an aggregate output of 350,000 tons per annum. The rich deposits of

phosphates in Tunis furnish the raw material for many Italian makers.

Metallisation of Textile Fibres.

According to a French patent (447,931) it has been found that a coating of casein does not adhere very strongly to bare fibre, but adheres well to a fibre that has been coated previously with a mixture of gelatine and a powder insoluble in gelatine. It suffices for the purpose that the paste of casein should be charged with a metallic powder, and so a very durable metallic appearance may be imparted to the fibre without any of the faults of processes hitherto practised. The object is attained by passing the fibre through a mixture of 250 gms. of gelatine, 250 metallic powder, and 500 water, then drying and passing through a mixture composed of 150 gms. of casein, 50 borax, 800 water, and about 300 of metallic powder and, finally, dry quickly.

Russia and Poland as a Market for Chemicals.

The *Vyestnik Finansov* of St. Petersburg has recently published an article drawing attention to the intensive agriculture which is practised in Russia, and to the increasing use of chemical manures. The average annual consumption of the latter in Russia during the last ten years has been 13 million pouds (1,000 pouds equals about 16 tons), of which 6,400,000 pouds were superphosphate and 4,500,000 pouds slag. The increase is particularly remarkable in recent years, the imports having risen from 9,000,000 pouds in 1908 to more than 24,000,000 pouds in 1911.

A Canadian Bureau of Chemistry.

In a recent issue of "Industrial Canada," T. Linsey Crossley pleads for the establishment of a Government Bureau of Chemistry for Canada, which would give Canadian manufacturers much valuable information by the analysis of raw materials or the goods of foreign competitors. The writer points out the beneficial results of the United States Bureau of Chemistry, which are appropriated by Canada. These results should, however, stimulate her to make efforts of her own. A proposal to equip a Forest Products Laboratory has been made, and it appears opportune to emphasise strongly the need for a well-organised Bureau of Chemistry, and the correlating or consolidating of the various units now working under separate departments.

The laboratories need not be located at one place, but should be parts of one system under a central head. Any recognised Canadian university or technical school, having well-equipped laboratories for special work, might become the centre for some one distinct branch of industrial and chemical research. Well-known consulting chemists and chemical technologists in the various centres could be appointed referees for the branches of industrial chemistry in which they specialise.

In every branch of industry the need is felt for the exploitation and adaptation of new raw materials and by-products. Private consulting and analytical chemists cannot afford time or space to engage largely in such work, and university laboratories are not equipped to do it. Very important work in a Government Bureau of Chemistry would be the standardisation of industrial raw materials, the preparation of standard typical specifications, etc., which would go far toward the accomplishment of Canada's industrial destiny.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.

885/12. VICKERS, LIMITED, and J. L. BENTHALL. Armour Plates and Steel Treatment.

In the manufacture of armour plates and other articles from nickel steel alloyed with one or more of the metals, chromium, molybdenum, vanadium, tantalum, tungsten, the plate or article is subjected, after cementation, to a succession of heating and cooling treatments prior to the machining, and to a succession of heating and cooling treatments subsequent to the said machining, but prior to the final or "differential" hardening.

1664/12. J. TANNE and G. OBERLÄNDER. Process for the Separation of Solid Paraffins, particularly Ozokerite-like Hydrocarbons, from Mineral Oil Residues, and Viscous or Semi-liquid Natural Products.

2190/12. J. FORSTER. Treating Waste Tanning Liquors.

3008/12. G. L. DAVIES and W. E. WINDSOR RICHARDS. Manufacture of Paint.

6080/12. FARBERWERKE, VORMALS MEISTER, LUCIUS und BRÜNING. New Sulphurised Dyestuffs.

8227/12. S. H. BLICHFELDT. An Improved Margarine.

8547/12. S. POPE. Manufacture of White Lead.

8554/12. T. GARE. Method of Reforming, Vulcanising and similarly Treating Indiarubber.

8712/12. LA SOCIÉTÉ ANONYME DES COMBUSTIBLES INDUSTRIELS. Conversion of Coal Tar, Petroleum Residues, Creosote and Schist Oils and the like into Pitch.

8991/12. A. C. CHAPMAN. Malt Liquors.

The nutritive value of any malt liquor is improved by adding to the malt liquor at any stage of its production subsequent to the beginning of the usual operation of mashing with water, protein matter predigested by a peptonising or pancreatising ferment.

9463/12. T. S. HAMILTON. Purifying Hydrocarbon Liquids.

A method or process for purifying hydrocarbon liquids consists in introducing the hydrocarbon liquid, preferably in a finely-divided state and under heavy pressure, into a tank containing a saline solution which will combine with such liquid to form an emulsion, in agitating the mixture to produce such emulsions, in effecting the removal of the emulsion, preferably in a continuous stream, from the tank and in subjecting the removed emulsion to shock or jar to separate the impurities from the pure oil contained therein.

9574/12. H. LEVINSTEIN and LEVINSTEIN, LIMITED. Mono-azo Dyestuffs.

Mono-azo dyestuffs are produced by combining a mono- or dinitro derivative of ortho-amino-phenol with a dinitro-phenyl-beta-amino-oxy-naphthalene-sulphonic acid.

9586/12. DEUTSCHE SPRENGSTOFF ACTIENGESellschaft. Liquefying Solid Nitro Bodies or other Chemical Substances.

9603/12. F. WOOD. Testing the Consistency of Bitumen, Tar and like Liquids.

9719/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & Co. Manufacture and Production of New Sulphide Colours.

10108/12. A. W. EMPSON. Brazing Flux.

The flux is composed of a mixture of alkali carbonates and a suitable boron compound.

10352/12. FARBERWERKE, VORMALS MEISTER, LUCIUS und BRÜNING. New Derivatives of Phenyleinchoninic Acid and of Homologues and Derivatives thereof.

10370/12. J. E. JAMESON, O. H. VALPY and E. A. BUCKLE. Treatment of Peat.

In a process for the extraction of water from peat, an electric current is passed through a pulp of the same heated to a temperature of, at least, 100° C. under a pressure such that no steam is produced.

10381/12. A. E. BOURCOUD. Reduction or Oxidation of Metallic Ore.

10443/12. FARBERWERKE, VORMALS MEISTER, LUCIUS und BRÜNING. New Derivatives of Phenyleinchoninic Acid and of Homologues and Derivatives thereof.

11090/12. W. DUBILIER. Apparatus for the Production of Ozone.

11347/12. SMITH REFRIGERATING CO. Process of and Apparatus for Refrigerating by Ammonia Expansion and Absorption.

11391/12. S. PEACOCK. Ammonia.

The process of producing ammonia consists in subjecting aluminum cyano-nitride to the action of steam at a pressure of substantially five atmospheres.

11392/12. S. PEACOCK. Titanium Cyano-nitrides and Carbides.

In the process of producing the titanium compounds referred to, a titanium compound, such as the oxide, mixed with carbon, is heated under a total pressure not substantially less than two atmospheres and to a temperature sufficient to produce said compounds, while the partial pressure of the evolved carbon monoxide is maintained not substantially higher than 200 millimetres of mercury.

11439/12. DEUTSCHE GASGLÜHLICHT AKTIENGESellschaft (AUERGESELLSCHAFT). Drawing Tungsten Wire.

The method of lubricating tungsten wire during drawing while the wire is hot, consists in applying to the wire either partly dehydrated acids or salts of such acids which are viscous at the temperature of the wire as it enters the die.

11643/12. W. E. GIBBS. Tin Extraction.

12095/12. A. TURNER. Water Soluble Dyestuffs.

12163/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & Co. New Sulphur Dyes.

A process for producing new sulphur dyes consists in heating the nitro- or amino compounds of phthaloperinone or of its substitution products with polysulphides in the presence of copper or copper compounds.

12542/12. J. R. C. MARSH. Treating Cast Iron and Steel.

A composition of matter for treating iron and steel consists of a mixture containing titanium, chromium, copper and boron.

12597/12. R. A. MAN. Paper Making.

In the process of making paper stock, vegetable matter

is treated with zinc chloride so as to change the non-fibrous insoluble constituents of the matter into a cementitious material.

12720/12. W. B. DAVIDSON. **Gas Purification.**

A process for the purification of illuminating, coke oven or other gas consists in first removing a large proportion of the carbon dioxide contained in such gas by bringing the gas into contact with either gaseous or liquid ammonia, then removing the ammoniacal liquor at this stage from the primary scrubber and distilling it and subsequently subjecting the gas to a further treatment using an ammonia solution or gas to absorb the sulphuretted hydrogen and carbon dioxide remaining.

14254/12. THE BRITISH CYANIDES COMPANY, LIMITED, and E. C. ROSSITER. **Sodium Alloys.**

An alloy of sodium is manufactured by heating caustic soda with carbon or a carbon yielding compound and agitating the metallic sodium so produced with molten metal.

14464/12. M. PRAGER. **Calcining or Roasting Furnace.**

14498/12. BADISCHE ANILIN UND SODA FABRIK. **Anthracene Series Compounds.**

Compounds of the anthracene series are manufactured by treating dibenzanthrone with an oxidising agent.

15720/12. F. W. DOBSON. **Bleaching Wood Pulp.**

In the bleaching of chemical wood pulp, the material is placed in a dry or semi-dry state in a closed rotatable vessel, sufficient water is then added to cause the material to become limp and weak and when the vessel is rotated to be reduced to a dry or semi-dry macerated condition. After the addition of water the vessel is rotated, and after rotation a concentrated bleaching liquor is added to the pulp and the vessel again rotated.

15966/12. J. W. BOYD. **Hardening Iron and Steel.**

A method of hardening iron and steel consists in heating the same in a fluid to which charcoal has been added and then quenching in oil.

16440/12. G. KAHLER and F. JUNKER. **Preventing the Spreading and Effect of Coal Dust and Fire Damp Explosions.**

17724/12. A. L. LEIGH. **Kilns or Furnaces for Calcining or Roasting Ore, Limestone or other Material.**

17836/12. N. H. M. DEKKER. **Electrolytes for Use in Electrometallurgy.**

TRADE ITEMS.

We are informed that as a result of negotiations between the General Baekelite Company and the Condensite Company of America, the suits brought by the former against the latter and its customers for alleged infringement of the Baekelite patents have been withdrawn, and the Condensite Company has acknowledged the validity of the Baekelite patents, and will pay substantial royalties thereunder.

We have received a catalogue from the Metallic Compositions Co., Ltd., of 265, Gray's Inn Road, London, containing information concerning the supply of technical and pure metals, in all forms for use in chemical, metallurgical and physical laboratories, and in research. The price list of alloys is a comprehensive one, and the same remark may apply to that of the metals themselves. Special fusible and light alloys are mentioned. This firm

also specialises in galvos metallic paints, enamels, bronze powders, varnishes, etc.

Messrs. Read Holliday and Sons, Ltd., have issued a pocket book for the use of dyers, which contains a mass of information about their special products, and also useful data concerning dyeing and printing generally.

The Magadi Soda Co., Ltd., have already started to erect works on the Manchester Ship Canal, seven miles west of Manchester. The position of the works will thus be situated in the largest soda consuming centre in Britain. The export conditions from the Canal are said to be no less advantageous. The Magadi Soda Company hope to secure a share of the soda trade in the home market, not only for pure soda ash, but also for various other soda products, such as caustic soda, bicarbonate of soda and soda crystals. This new source of supply is expected to be available during next year.

SHARE LIST.

Name of Company.	June 24th.	May 24th	May 24th
Alby United Carbide	1 1/2	1 1/2	1 1/2
Ditto. Pref.	3 1/2	1 1/2	1 1/2
Associated Portland Cement. (10)	6 1/2	6 1/2	7 1/2
Ditto. Pref. (10)	8 1/2	8 1/2	8 1/2
Babcock-Wilcox. Ord. ..	2 1/2	3	2 1/2
Ditto. Pref.	1 1/2	1 1/2	1 1/2
Bell's United Asbestos	1 1/2	1 1/2	1 1/2
Bleachers' Association. Ord. ..	3 1/2	3 1/2	3 1/2
Ditto. Pref.	1 1/2	1 1/2	1 1/2
Borax Consolidated. Pfd. (5)	5 1/2	5 1/2	5 1/2
Ditto. Defd.	1 1/2	1 1/2	1 1/2
Ditto. Pref. (10)	10 1/2	11	11 1/2
Bradford Dyers	1 1/2	1 1/2	1 1/2
Ditto. Pref.	1 1/2	1 1/2	1 1/2
British Oil and Cake. Ord. ..	3 1/2	3 1/2	3 1/2
Brunner Mond. Ord.	4 1/2	4 1/2	4 1/2
Ditto. 7% Pref. (10)	14 1/2	15 1/2	15 1/2
Bryant and May. Pref.	2 1/2	2 1/2	2 1/2
Calico Printers	1 1/2	1 1/2	1 1/2
Ditto. Pref.	3 1/2	3 1/2	3 1/2
Castner Kellner	3 1/2	3 1/2	3 1/2
Commercial Salt. (2/-)	7 1/2	7 1/2	5/-
Crossley & Sons. (2)	1 1/2	2	2
Ditto. 5% Pref.	4 1/2	5 1/2	4 1/2
Eastman Kodak. (\$100)	600	650	690
Eley Brothers	1 1/2	1 1/2	1 1/2
Fraser and Chalmers. (£3)	1 1/2	2	1 1/2
Gas Light and Coke. (S.) ..	100	102	102
Ditto. 4% Pref. (S)	94	96	94
Greenwich Lino. (1/2)	3 1/2	3 1/2	3 1/2
Harrison and Crossfield. Pref. ..	3 1/2	1 3/4	1 3/4
Imperial Continental. (S)	160	165	167
Ditto. 3 1/2% Debenture (S)	85	87	85
India Rubber Co. (10)	11	12	11
International Salt	6/-	7/-	9/-
Ditto. Pref. (5/6 pd.) ..	1 1/2	1 1/2	2 1/2
Lever Brothers. 1st Pref. (10)	11 1/2	11 1/2	11
Lister & Co. Ord.	1 1/2	1 1/2	1 1/2
Mappin & Webb. Ord.	1 1/2	1 1/2	1 1/2
Neuch'el' Asphalt. (10/-)	9	9 1/2	9 1/2
Nobel Dynamite. (10)	16 1/2	17 1/2	17 1/2
Ditto. Bearer (10)	16 1/2	17 1/2	17 1/2
Ditto. 5% Pref. (10)	10 1/2	11 1/2	11
Pears, A. and F. Ord.	1 1/2	1 1/2	1 1/2
Ditto. 6% Pref. (10)	11 1/2	12 1/2	11 1/2
Price's Candle. (16)	35	37	35
Rosario. (5)	8 1/2	9 1/2	9 1/2
Salt Union. (4)	3	3	3
South Metropolitan 4% Standard (S)	108	110	110
Ditto. 3% Debenture (S) ..	73	75	73
United Alkali. (10)	1 1/2	1 1/2	1 1/2
Ditto. Pref. (10)	9 1/2	9 1/2	9 1/2
Val de Travers	1 1/2	1 1/2	1 1/2

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* *

that there is no known method by which the seller can convince the manufacturer that he is wrong in his estimate, for analysis of rubber is not received as an absolute indication of its value. When it is remembered that the product from a single tree will be inferior at three years and satisfactory at, say, six years, the problem set before the analyst is obviously a difficult one.

In the general review of the position, the scientific adviser has not apparently escaped all blame. It has been thought in some cases that increased output has been obtained by tapping too young trees. If it is found that this is the chief cause of the variations which have seemingly occurred, the steps which the companies are taking will improve matters. In some way or other the variations obtained between two lots of crepe, or hand-sheet, as judged by appearance, or the "hand pulling" test (which answers as a guide in the Brazilian article), are not disclosed by such a preliminary examination of cultivated rubber. There is little wonder that the manufacturer will not buy on full prices an article which cannot be judged by the only tests he has at his command.

The chemist must in some way supply a satisfactory and generally recognised test which will correspond to results obtained in practice, and this is always a difficult matter. It is doubtful whether such a test exists to-day. The suggestion that the cultivated product is an emasculated one will have to be met or the cultivator will still find himself in the hands of the manufacturer. There can be little doubt but that further experience will produce a less variable product. The preliminary operations dealing with coagulation will probably have to be standardised, as variations in this direction may be partly responsible for the differences which so mystify the manufacturer. The report of the influential committee which the Rubber Growers' Association has formed to consider the whole matter, will be awaited with some impatience by those interested in the cultivation of the rubber plant.

Explosions in Air Compressors.

The increased use of air compressors, liquefying plant, and, to a certain extent, large gas engine units, has brought up the question of a new danger which may be present where such machinery is employed. A recent article in *The Times Engineering Supplement*, which deals with this risk with air compressors, is of interest. The cause of such explosions as have taken place is probably connected with the presence of an inflammable gas in the cylinder of the compressor or in some of its accessory portions. Where this is present in quantity sufficient to form an explosive mixture, and when in some way or other this is raised to a sufficient temperature to cause ignition, certain unpleasant results may follow. So far as it is known at present, these inflammable gases may have their origin, either in the oil used to lubricate the cylinder or else carbon monoxide may be formed *in situ* by the oxidation of a deposit of carbon. It is thought that the latter gas is responsible for a large proportion

of the explosions which have taken place. Deposits of carbon may form from the lubricating oil, or from dust which enters from the inlet port, or even from both. In the case where it is due to the lubricating oil, a suitable variety has not been chosen, and by careful attention to this point, the risk may be undoubtedly reduced.

In the case where it has its origin in dust, the compressor has generally been working in the neighbourhood of a colliery. It is known that such deposits of carbon, however they may be formed, will absorb oxygen when a quantity of air is passed over them, and that the rate of absorption increases with temperature, so that the temperature of the deposit of carbon, once it reaches a certain quantity, or thickness, may increase until the ignition point is reached. The ignition temperature of carbon monoxide is about 1,200° F., and this temperature may easily be produced, locally, by the heating effect caused by the sticking of the outlet valve. Explosions of this nature, in addition to those which have occurred under certain conditions from the presence of lubricating oil in excess in large unit gas engines, which, in one case, at least, entailed disastrous consequences and loss of life, are disconcerting phenomena. They are specially interesting to the chemist, as he alone will probably have the necessary data to trace their origin, and also from the fact that such machinery is entering so largely into operations of an electro-chemical or kindred nature. It is also evident that the use of such machinery will tend to increase in the future, and it is, therefore, necessary wherever the chemist meets with the same (especially in large units) that the possibility of such phenomena occurring must receive serious attention, and every means taken to reduce the chance of their occurrence to a minimum.

Hard Water Fallacies.

Under the above title the *Lancet* recently discussed the effect of lime in potable water, from the medical point of view. It is pointed out that the supporters of the view that hard water (through its contained lime salts) may have a bad effect on the system have failed to consider that, quite apart from this possible supply, lime salts are present in the common everyday articles of food. So that, if hard water were left out of the dietary, there would still be secured "a large intake of lime salts which could only be avoided by a hunger-strike." It is also pointed out that, on theoretical considerations, an infant requires at least 4 grs. of lime daily, and that a tumbler of hard water contains 1, or at most 2, grs. of chalk, so that it would be difficult to introduce in the economy more than 10 grs. of lime per day by such means, when assuming the water to be very hard. This amount is an almost negligible one when it is remembered that a pint of milk contains more lime salts than a pint of lime water. Eggs, the cereals, and vegetables also contain lime in quantity. It is thus seen that the amount of lime salts taken through food easily exceeds the quantity present in many gallons of hard water.

THE ORIGIN OF PETROLEUM.

By E. JOBLING, A.R.C.Sc., B.Sc.

FOR the chemist, more even than for the geologist and prospector, the question of the origin of petroleum has always exercised a peculiar attraction. This is evident from a consideration of the great names in chemistry which were associated with the problem in its earlier phases and from the number of chemists who have contributed to its subsequent development. The attraction—that of the unsolved, or, better, the incompletely solved—is as great as ever. We still lack a comprehensive co-ordination of all available facts. The ideal hypothesis, however, can only be reared on the ruins of the old; and it would therefore not be out of place if, at this stage, existing theories were briefly reviewed and criticised with a view to the elimination of the worthless and the consolidation of surviving features.

First, as to the body with which the theories deal. Petroleum, as is well known, consists of a mixture of numerous hydrocarbons, which may be conveniently divided into two homologous series—the paraffins, C_nH_{2n+2} ; and the naphthenes C_nH_{2n} —the former being chain and the latter ring compounds. The character of the petroleum depends largely upon the proportions of these constituents; in the Pennsylvanian type the paraffins predominate, whilst naphthenes are the primary constituents of the Baku variety. Accompanying these main components are small proportions of the members of other classes of hydrocarbons—olefines, benzenes, terpenes and other unsaturates, as well as varying quantities of organic sulphur compounds, nitrogen bases and some oxygen-containing compounds, whilst in the residue, after distillation at 300°C . are to be found solid hydrocarbons and thick oils belonging to the polynaphthenes.

With this brief introduction, we will proceed at once to a discussion of the various theories of its origin.

The interaction of water and metallic carbides has long been known to produce simple hydrocarbons, and upon this fact most of the chemical theories have been based. The elaborate enquiry of Moissan into the formation and properties of carbides gave to these theories a new lease of life, with the result that a few, in a modified condition, persist even down to the present time. The earliest and most fantastic assumed that when the earth reached its *consistentior status*, the hydrocarbons produced by the direct union of carbon and hydrogen (Sokoleff) or by the interaction of steam and glowing metallic carbides (Adadurow) condensed upon the earth's surface or separated from the cooling magma. The vast accumulations of petroleum were thus explained, altogether ignoring such elementary facts as that oil never occurs in the Archæan formation, or that none is to be found in the sea. Similar theories,

based upon the idea that the products of the interaction of carbides and water in the earth's bowels have been distilled by internal vulcanicity to the upper cooler layers, are also *prima facie* unworthy of consideration, for a complex mixture could not be so distilled, nor would the oil's optical properties survive the severe temperature conditions. Quite as untenable are those theories coupled with the names of Berthelot and Mendeléeff. The former in 1866 expressed the view that by the infiltration of water containing carbon dioxide into the interior of the earth—supposed to contain free alkali metals at a high temperature—the formation of petroleum resulted; whilst Mendeléeff, basing his argument upon the belief that the interior of the earth contained large amounts of iron and its carbide, opined in 1877 that petroleum was to be attributed to the penetration of water to the carbide, consequent perhaps upon terrestrial upheavals.

Both of these theories have had many advocates, and even to-day their plausibility appeals to some. But it is clear that they rest upon the assumption that alkali or other metals are present in the uncombined state below the surface of the earth—an assumption which is most probably erroneous. It is only fair to add, however, in justice to Mendeléeff's hypothesis, that Becker has recently observed certain magnetic irregularities in connection with oil-bearing regions which lead him to believe that iron is present below, but the evidence is admittedly inconclusive.

One of the most serious objections against any "inorganic" theory, so far alluded to, is that of bridging the gap between the simple hydrocarbons which are the product of the interaction between metallic carbides and water, and the complex hydrocarbons of which petroleum is built up. The difficulty has been removed fairly recently by the classic experiments of Sabatier and Senderens upon the hydrogenation of elementary hydrocarbons. They observed, for instance, that by the passage of acetylene and hydrogen over finely-divided nickel or cobalt or iron, between certain limits of temperature, an oil is formed which closely resembles the petroleum of Pennsylvania. Over nickel at a higher temperature, a product corresponding to Caucasian petroleum resulted; whilst at a higher temperature still the Galician type was obtained. Assuming then, as before, that the interior of the earth contains free metals together with carbides, and that metals of the nickel group occur in the higher strata, the hydrogen and acetylene developed in the respective cases by interaction with infiltrating water might enter into combination and give rise to earth-oils of different characters, according to the mixture proportions and the temperature conditions.

Serious objections, however, can be urged against

the theory. In the first place, the fundamental assumption as to the prevalence of metallic carbides is open to question, for carbides have not yet been found in eruptive material; and in the next place, it has recently been shown that dry steam and metallic carbides do not interact (Hahn).

Cosmology, too, is against any process which argues from the premises that the products of chemical action ascend through the strata, since it would be impossible to reconcile the present occurrence of oil in well-defined zones with, perhaps, dry intermediate strata; or to account for the fact that oil reservoirs, when once exhausted, are never renewed from below. Further, the optical activity of petroleum presupposes the absence of vulcanicity as a factor in its formation, and thereby militates against any synthesis from simpler substances.

We are thus driven back, in the quest for a reasonable theory, upon the three fundamental ideas of formation *in situ*, at a low temperature, by a process of degradation from some more complex material. The only theories answering these requirements are those which ascribe the origin of petroleum to organic material, *i.e.*, to the slow decomposition of vegetable or animal matter occurring in the various geological formations.

The difficulty at once presents itself as to the circumstances which could possibly determine the accumulation of sufficient organic *débris* to account for the vast quantities of petroleum occurring in the earth's crust. Obviously, the conditions must have been abnormal, not only in the unparalleled profusion of organic life which they occasioned, but also in their almost complete inhibition to putrefaction.

In the case of vegetable accumulation, Lewes has put forward some very interesting views. The prehistoric atmosphere is credited, and not without reason, with a superabundance of carbon dioxide, which has been absorbed at certain periods of geological time by a prolific growth of vegetation, and which, at the same time, has ensured a minimum of surface decay in the remains which accumulated. These vegetable remains may have been either terrestrial or marine. The difficulty with terrestrial deposits is that some trace of the fibrous structure would almost certainly have persisted, whereas oil contains no trace of fibrous material. Marine vegetation, which is almost structureless, forms a more likely source; and assuming, therefore, that the above conditions obtained, by which a luxuriant growth of seaweed took place, say in shallow tepid seas, the origin of petroleum is reasonably traced. There is only one important difficulty then to be removed, *viz.*, the absence of bromine and iodine compounds in petroleum as against the fact that seaweed contains fair quantities of these salts. The discrepancy, however, disappears when it is remembered that the early seas probably contained no salts whatsoever, the present concentration being the result of long denudation of the earth's surface.

An attempted justification for the belief in an animal origin of petroleum is perhaps not so successful. Land animals are out of the question; so that we must fall back upon some cataclysmic destruction

of marine fauna such as would take place, for instance, as the result of a succession of sandstorms in which the blown sand was deposited in the sea, or by the incursion of brackish into fresh water, consequent upon the inroad of the sea into an inland lake. If the dead fish became soon covered over by sediment or the decomposition supposed to be retarded by the antiseptic sea-salt (a substance which usually accompanies petroleum), a potential oil reservoir might conceivably come into being. It would be difficult, however, to assume a series of these phenomenal conditions such as the present widespread character of petroleum deposits would require, though Engler, Höfer and other German chemists rather favour the idea.

Assuming, nevertheless, that organic remains might give rise, on geological grounds, to petroleum accumulations, let us consider the chemical and physical evidence in favour of these views.

Take the "animal" hypothesis first. The fact that fish scales and traces of foraminifera have been found in oil deposits supports the claim of fish and other sea-dwelling to be accounted the primeval material, more especially as laboratory experiments have shown the process of their transformation to be practicable. Höfer lays emphasis upon the fact that oil is often found in strata containing animal but no vegetable remains, and that, in one instance at least, an exudation of oil has been observed from a coral reef, where an animal origin alone is possible. Against these arguments, however, and in addition to the objection already referred to, is the doubt raised by a consideration of the nitrogen-content of petroleum as compared with that of animal remains. Petroleum is relatively nitrogen-free, and to reconcile this with the comparative richness of animal remains, a peculiar decomposition, not experimentally confirmed, must be assumed. The nitrogen-containing bodies, largely proteins, are supposed to develop during putrefaction volatile nitrogenous products, leaving behind only the nitrogen-free fats, from which latter it has been experimentally shown that it is possible to get all the essential constituents of natural oil. Thus Engler has distilled menhaden oil, a mixture of oleic, stearic and palmitic acids (which behave like their esters in this respect) and obtained a petroleum-like distillate, whereas a similar procedure with dried fish, where the original nitrogenous bodies had not been eliminated, was quite unsuccessful.

The difficulty as to the nitrogen-content does not arise in the case of a vegetable origin. It is only necessary here to assume that the cellular material rots away, and that from the accumulated waxes, the oil results. As to whether oil or coal is the ultimate product depends solely upon the conditions—temperature, pressure and richness or otherwise in the necessary fatty material. The slow decay of vegetable matter under water in the absence of air is undoubtedly the only process which yields a gas resembling natural gas, and it is reasonable to infer that by a lengthened process under high pressure petroleum might well be produced.

The "organic" theories, both animal and vege-

table, thus depend largely upon the transformation of fatty constituents into hydrocarbons, the preference being given to the vegetable origin of petroleum rather than the animal, because, of the accompanying materials, carbohydrates in the one case and proteins in the other, the removal of the former is the more readily explained. The probable course of the decomposition of the remaining fatty stuff is easily outlined. By contact with water, and to some extent by fermentation, saponification of the glycerides takes place, liberating the fatty acids themselves, and these, by loss of carbon dioxide and perhaps water, give rise to a solid hydrocarbon mixture. Of course, at ordinary temperatures and pressures, the process would be immeasurably slow, but by the increase of these factors consequent upon subsidence, acceleration would ensue. Further heating under pressure would produce liquid hydrocarbons. The naphthenes are supposed to result from isomerisation of the corresponding unsaturated fatty hydrocarbons, a reaction which is known to take place, though only by using aluminium trichloride at a high temperature and pressure. In the case of petroleum, however, it is certain that the production must have been spontaneous rather than destructive, *i.e.*, have occurred at a low or moderate temperature. Many, indeed, maintain that great pressure is the primary factor. In experiments upon the synthesis of coal by subjecting peat to high pressure in contact with water, Bergius (*J. Soc. Chem. Ind.*, 32, 462) has recently observed that the accompanying liquid consisted of a colloidal solution of hydrocarbons, from which, by contact with salt, the hydrocarbons were precipitated in a

form resembling petroleum. The hydrocarbons apparently resulted from the decomposition of the fats and waxes in the peat; so that the experiments furnish further evidence in favour of a vegetable origin of petroleum, as well as explain the presence of salt in the neighbourhood of petroleum deposits.

In conclusion, reference must be again made to the circumstance that all natural petroleum is optically active—which at once puts inorganic theories out of consideration and points unequivocally to an organic origin. This for two reasons. In the first place, racemisation is found to accompany every chemical synthesis in which an optically active compound might be anticipated; and in the second, the optical activity of petroleum has been traced (Marcusson) to a certain constituent, cholesterine, which is widespread in the animal and vegetable worlds.

From the above brief discussion, it will be seen that the evidence, though abundant, is to some extent contradictory, and a diversity of opinion regarding it is not unexpected. But whilst no theory warrants general acceptance, it is evident that "inorganic" theories are inadmissible, "organic" theories alone meeting the requirements. As to whether the original organic material was animal or vegetable, it is difficult to say. Different oil fields unfold different histories; so much so that our attitude at present can only be to admit that the sources may have been different for different districts, and that either animal or vegetable accumulation may have played the parental rôle.

CHEMICAL IMMUNITY ACQUIRED BY SOME PARASITES.

By M. NIERENSTEIN.

IN the treatment of diseases caused by protozoa one of the greatest difficulties met with is the power which some of the parasites possess of becoming resistant to the action of the specific drug used. Thus, the malaria parasites become immune to the action of quinine, the syphilis parasites to that of mercury, arsenic, etc.

The existence of this power in the case of trypanosomes (protozoa, which cause sleeping sickness, Nagana and other diseases) was first observed experimentally by Ehrlich (*Berl. Klin. Wochenschr.*, 1907, 310—314), and has since been the object of a number of investigations. Ehrlich found that on feeding mice infected with *Trypanosoma brucei* with paraformosan the trypanosomes disappeared from the blood for a long time. Eventually, however, they reappeared in the circulation, but could be banished again by a second course of feeding with paraformosan. But this could not be repeated indefinitely, as the intervals between the reappearances of the parasites (or "relapses") gradually became shorter, until finally, the drug had no effect on the parasites. In

this way had been produced a race of parasites able to resist paraformosan. Moreover, when a second mouse was infected with this race, the trypanosomes still maintained their power of resisting the drug. Ehrlich was next able to develop races of trypanosomes resistant to other trypanocidal agents, such as trypan-red, trypan-blue, atoxyl, arsenophenylglycine, and Riquier (*Pathologica*, 1912, 3, 286), has extended these experiments by producing a strain of *T. brucei*, which had become resistant to salvarsan, the well-known drug discovered by Ehrlich.

The resisting power of *T. brucei* against atoxyl in the mouse persists through a large number of generations; one race maintained its power of resistance after having passed through 140 mice during a period of fourteen months.

At the time (1907) when these results were published, the writer was engaged in work on similar lines, and experiments in mice were carried out with an atoxyl-resistant strain obtained from Professor Ehrlich's laboratory. It was found that after injection of an atoxyl-resistant strain produced in

German-bred mice into English-bred mice, the parasites remained resistant, whereas, after injection into white rats, dogs or guinea pigs no resistance could be noticed. To further examine the phenomenon, an atoxyl-resistant strain of trypanosomes was produced in the rat. Here it was found that the resistance was retained only in rats, and that it disappeared after injection into mice and other laboratory animals (*Ann. Trop. Med.*, 1908, 2, 221).

Mésnil and Brimont (*Ann. Inst. Pasteur*, 1908, 22, 856), extended these observations to *T. evansi*. This race they found to maintain its acquired power of resisting atoxyl unimpaired, even after 110 passages through mice without any fresh contact with the drug. Nevertheless, when this race was injected into rats the trypanosomes at once became susceptible to the action of atoxyl, all power of resistance having disappeared.

These observations were further extended by Breinl and Nierenstein (*Deutsch. med. Wochenschr.*, 1908, 34, 1181), who developed an atoxyl-resistant race of *T. equiperdum* in donkeys. They found that after inoculation of this resistant strain into rats and successive passage through guinea pigs, rabbits and rats, during a period of over seven months, no signs of resistance could be noticed in these animals, the parasites behaving quite normally. When, finally, a donkey was inoculated, it was found that the race had maintained its resistance even after all this time.

Of great importance is the work of Gonder (*Centralbl. f. Bakter.*, 1911, 61, 102), dealing with the question whether the acquired resistance is retained after transmission by the normal intermediate host. Experiments were carried out with *T. lewisi* (the rat trypanosome) which had been made resistant to arsenophenylglycine (the only organic arsenic compound by which *T. lewisi* is affected). As a transmitting agent he used the rat-louse (*Hæmatopinus spinulosus*) which normally carries the infection from rat to rat. Large numbers of lice were transferred from rats infected with drug-resistant trypanosomes to normal rats. The latter became infected, the parasites being resistant or non-resistant according to the mode of infection. If the parasites were carried in fresh rat-blood on the mouth parts of the lice, and thus mechanically inoculated into the new host the drug-resisting power was maintained. If, on the other hand, the trypanosomes had passed through a *developmental cycle* in the intermediate host (the louse), it was found that the new generation, developed in the freshly infected rat, had completely lost the acquired character of resistance to arsenophenylglycine. Accordingly, when rats were infected by lice in which the parasites had undergone a life-cycle, the trypanosomes, which developed in their blood, were quite normal, and disappeared from the circulation on the injection of arsenophenylglycine. Thus the acquired power of resisting a drug is eliminated by passage through the intermediate host. Hence, there seems little danger of races of *T. gambiense*, the cause of sleeping sickness, which have become resistant (by prolonged treatment of natives in

Africa), being spread by the tsetse-fly, its intermediate host.

Ehrlich (*vid. Beiträge zur experimentellen Pathologie u. Chemo-therapie*, 198—199) explains the drug-resisting power of trypanosomes towards organic arsenic compounds, especially atoxyl, by suggesting that the "chemo-receptors" of the trypanosomes have, through a continued administration of organic arsenic compounds, lost their "avidity" for the drug. Thus the "receptors," especially the "chemo-receptors," have become inactive towards the trypanocidal action of the As^{III} -radical, to which, according to Ehrlich, the action of all organic arsenic compounds is due.

On the other hand, Breinl and Nierenstein have shown that atoxyl does not act directly on the parasites, but only after it has entered into *combination* with the proteids of the blood (the newly-formed compound they term "atoxyl-serum") and regard the resistance of the parasite as an immunity acquired against the "atoxyl-serum" (*Zeitsch. f. Immunitätsforschung*, 1909, 1, 630, and *Ann. of Trop. Med.*, 1909, 3, 413). Thus, when a race has acquired the power of resisting the compound of atoxyl with mouse-proteid it does not necessarily possess the power of resisting the "atoxyl-serum" of the rat, since the blood proteids of different animals differ. The fact that the resistance acquired in one species is lost on transmission into another is thus easily explained. Ehrlich's assumption obviously does not explain all the facts as there is no reason why resistance due to the loss of chemical receptors should change on transmission from one species to another. Furthermore, if Ehrlich's view is correct some cytological change would be expected in the parasites on the acquirement of resistance against organic arsenic compounds, as is observed in the case of ortho-quinoidal colouring matters which cause the disappearance of the blepharoblast in the trypanosomes (Werbitzki, *Zentralbl. f. Bakter.*, 1909, 303). Atoxyl, arsenophenylglycine and acetatoxyl, however, even after three or four years, produce no cytological changes in the parasites. (Werbitzki, *loc. cit.*).

Owing to experimental difficulties, much less is known with reference to acquired resistance in the case of malaria, syphilis and similar protozoan diseases. Here, the interesting work of Neiva (*Memorias do Instituto Oswaldo Cruz. Rio de Janeiro*, 1910, 1, 131) should be mentioned, which, though not quite conclusive, has brought forward a great deal of evidence in favour of the view that the resistance against quinine acquired by the malaria parasites greatly resembles that of trypanosomes. As was shown by Gonder (*loc. cit.*) for trypanosomes the quinine-immunity acquired by the parasites is lost on passage through the intermediate host, the anopheles-mosquito.

In conclusion, the observations of Bilfinger (*Med. Klinik.*, 1911, 486) and of Morgenroth and Rosenthal (*Beit. f. Hyg. u. Infektionskrankh.*, 1912, 501) have shown that the drug-resistance is often reduced by the introduction of a second anti-parasiticum. Thus atoxyl-resistant trypanosomes

lose, to a slight extent, their resistance against atoxyl on treatment with dihydroquinine which has a trypanocidal action. Similarly malaria para-

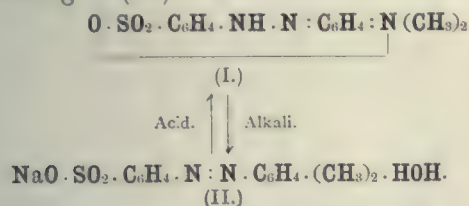
sites which have acquired an immunity against quinine become less resistant to this drug after injections of salvarsan.

THE CONSTITUTIONS OF HELIANTHIN AND METHYL-ORANGE.

BY A. W. STEWART, D.Sc.

It is now a well-recognised fact that the alteration in colour during the usual reactions of indicators is to be attributed, not to mere ionisation, but to an actual isomeric change in the structure of the indicator molecule, as was suggested by Hantzsch and by Stieglitz. This solution of one problem, however, merely brings us face to face with a fresh one; for the constitution of the two isomerides remains to be discovered.

Up to last year (see Henrich, *Theorien d. organ. Chemie*, 1912) it was assumed that in the case of methyl-orange, this problem had been solved; as it was taken for granted that the red solution of helianthin contained a quinonoid acid of the structure (I.) while the yellow alkaline solution of methyl-orange owed its colour to the presence of an azo-body corresponding to (II.)—



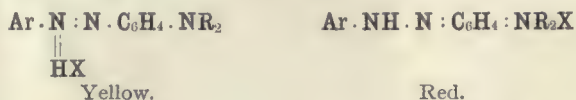
In a recent paper, Hantzsch (*Ber.* 1913, 46, 1537) has reopened this question with rather surprising results. In the first place, he has shown that solid helianthin, which is a yellow substance, can be turned dark red by merely scraping it on a tile; the red product on standing returns to the original yellow tint. Further, alkyl derivatives of helianthin, which are dark red in colour, yield canary yellow solutions when dissolved in dry acetone or alcohol. Even when a trace of acetic acid is present in these solutions the yellow colour remains unaltered; but if water be added to the acidified solution, a deep-red tint is produced at once. This proves conclusively that the change from red to yellow is not caused by the alteration of the liquid from acid to alkali; and it seems probable that the existence of yellow helianthin in a solution is not due to the presence of hydroxyl ions but must be ascribed to the absence of hydrogen ions. It will therefore be much influenced by the character of the solvent; one which does not permit the formation of hydrogen ions (such as acetone) gives yellow solutions.

Now it had been observed by Thiele (*Ber.*, 1903, 36, 3965) that some amido-azo compounds give two hydrochlorides of different tints; and Hantzsch (*Ber.*, 1908, 41, 1172) had described chromoisomeric salts of amido-azo derivatives, one set being dark

violet while the others were yellow. In helianthin and its derivatives, we evidently have an analogous case. An examination of the substances with the spectrograph has led to somewhat unexpected results. The curves show that we can trace three distinct types among the derivatives. We have, in the first place, the halogen-alkylates of the formula $\text{C}_6\text{H}_5 \cdot \text{N}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{N}(\text{CH}_3)_3\text{X}$. These bodies are unmistakably allied to ordinary azobenzene; and they probably possess the usual azo-structure. Next we have yellow salts of dimethyl-amidoazobenzene, such as the oxalate: $\text{C}_6\text{H}_5 \cdot \text{N}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{N}(\text{CH}_3)_2 \cdot \text{C}_2\text{H}_2\text{O}_4$; and its curve differs from that of the halogen-alkylate. Finally, with a third distinct spectrum, we have the red hydrochloride $\text{C}_6\text{H}_5 \cdot \text{N}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{N}(\text{CH}_3)_2 \cdot \text{HCl}$. Yellow helianthin falls into the second category, according to the spectra; while red helianthin is analogous to the red hydrochloride.

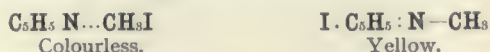
Now on this evidence, we must conclude that yellow helianthin is not an azo-derivative; so that the customary explanation of the colour change on the ground of a conversion of an azo-derivative into a quinonoid one falls to the ground: and we must seek some other hypothesis to cover the facts.

Hantzsch has discussed the possibility of the yellow and red salts being structural isomerides of the following types:

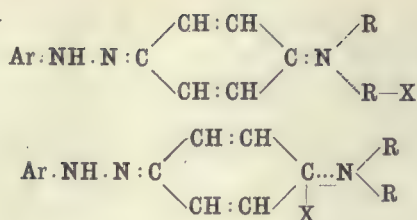


But he rejects this hypothesis on account of the close similarity of the absorption spectra of the two forms, which is greater than one would expect from substances of such different constitutions.

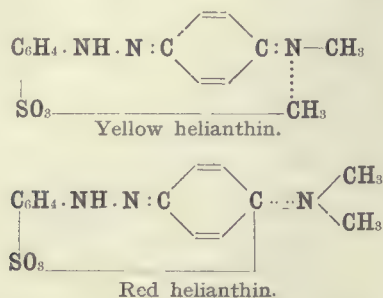
If we exclude the idea of structural isomerism, the only other line of explanation which suggests itself at present is valency isomerism; and Hantzsch has been driven to accept this hypothesis. Turning to the case of the alkyl-pyridonium iodides, we find that two isomeric forms exist, one of which is colourless, while the other is yellow in tint; and it has been suggested that these compounds differ from each other in the manner of attachment of the alkyl iodide to the pyridine nucleus. Hantzsch expresses this idea in the following formulæ:—



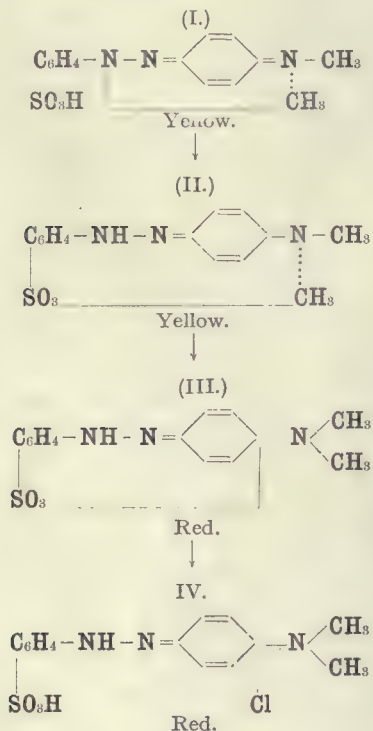
and with the same assumption he writes the amidoazo-salts thus:—



Now let us apply this idea to the two forms of helianthin, and we shall obtain the isomeric structures:—



If these formulæ be taken as correct, then the change of colour in the indicator is to be ascribed, not to a structural change between the azoid and quinonoid forms, but to a valency-isomeric change from the internal ammonium salt of the yellow series to the corresponding one of the red series, and *vice versa*; but it should be noted that this view leaves us, after all, with no explanation of the action of the hydrogen ions; and we still have to take their influence as an experimentally established fact to account for which we have no hypothesis.



At this point it may be well to summarise Hantzsch's views of the indicator action. The

reversible change of yellow methyl-orange into red helianthin, according to him, takes place in the following stages. First, we have present in alkaline solution the yellow sodium salt. Now when we reduce the amount of alkali present, the first product is a yellow acid (I.) which is constituted analogously to the sodium salt. As soon as this acid is liberated, however, it goes by intramolecular change into the yellow internal salt (II.). When the solution is acidified, the yellow salt (II.) is converted into the isomeric red variety (III.); and further addition of acid changes this last body into an analogously constituted red hydrochloride (IV.). So much for the indicator question.

In the course of this work, Hantzsch has discovered a further possible isomeric change in the amidoazobenzene series. We have already seen above that the dialkyl-amidoazobenzene compounds, including the halogen alkylates, give rise to three series of salts; a yellow azoid type, a yellow and a red quinonoid group. These substances, owing to the presence of the alkyl radicle are not capable of a re-arrangement which is possible with the parent amidoazobenzene:—



Now Hantzsch has shown that amidoazobenzene, in addition to the three salts mentioned above, can yield a fourth isomeric form, which is almost as black as graphite and which is crystallographically distinct from the others. He suggests that the new black salt may be a quinonimine derivative of the type expressed in the above formula; and this agrees with the fact that the new type of salt cannot, apparently, be formed in those cases where a wandering of the amido-hydrogen atom is prevented as is the case with alkyl-substituted amido-groups.

What is White Lead?—Before Mr. Justice Avory, on July 9th, a settlement was announced in the case of *Raban and Son v. Thomas Merry & Co., Ltd.* The terms of settlement were as follows:—

"The defendants admit that, as alleged in the statement of claim, on a sale of goods by and under the description of white lead, or any of the descriptions aforesaid, it is a condition to be implied according to the usage and custom of the trade that the substance to be sold and delivered should be the substance commonly known as white lead, otherwise hydrated oxycarbonate of lead, and also admit that they supplied to the plaintiffs a pigment which was of a different description and composition, being composed, not of hydrated oxycarbonate of lead, but of sulphate of lead. The plaintiffs admit that the defendants did not make any representations intentionally or fraudulently so as to induce the plaintiffs to enter the said contract. And plaintiffs and defendants, in consideration of the respective admissions, have mutually agreed to settle the said action upon the terms and conditions hereinafter contained, so as to put an end to the action. The defendants hereby undertake that at all times hereafter they will not offer for sale, or sell and deliver in the course of their business, any substance or pigment under the name of "white lead" other than the substance or pigment commonly known as white lead, viz., hydrated oxycarbonate of lead."

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

THE REGENERATION AND RECUPERATION OF WASTE HEAT FROM FURNACE GASES.

By C. O. BANNISTER, A.R.S.M., M.I.M.M.

IN view of the great progress now being made in the scientific design of furnaces with a view of fuel economy, the value of gas-firing over direct firing is being fully recognised. Without either regeneration or recuperation of the waste heat from the furnaces, however, gas-firing has no great commercial advantage over direct firing, and a consideration of the principles involved may be of interest.

In either case, the heat of the waste gases is used for preheating the air for combustion, thus returning to the furnace, heat which would otherwise be lost to it. It is generally the secondary air or that used for burning the gas supplied to the furnace which is preheated, but in some cases the primary air or that used in the production of the combustible gas is also preheated, and in other cases, where the gas used is produced some distance from the furnace or is treated for by-products, this is also preheated.

As is well known, the principle of regeneration was first worked out by Siemens in 1856, but the great possibilities of this method of utilising the waste heat of furnaces were not completely proved and demonstrated until after the invention of the Siemens gas producer. The first complete plant of gas producer and regenerative furnace was built in Birmingham in 1861, and the system then introduced was so perfect that no essential change has since been made in his method.

This system is known as the reversing system of regeneration, and requires an arrangement of suitable valves whereby the hot waste gases are made to pass through the heat chambers containing checkered brickwork. The direction of the flow of the gases through the furnace is periodically reversed and the heat imparted to the checkered brickwork is transferred to the incoming air and gas. For very high temperature work both the air and gas used are preheated in this manner, but in furnaces, where only a moderately high temperature is required, the air only is preheated.

The system of recuperation, on the other hand, is continuous in action instead of being intermittent, and is known as the continuous, parallel, counter current system, and it is a surprising fact that although this method has been largely used in various forms and in many industrial operations, especially on the Continent, very little has been published on the subject.

In the best forms of continuous recuperative furnaces the recuperators consist of specially manufactured tubular bricks which are made with ribs on the outside, on the top and bottom only, these ribs being at right angles to the run of the hollow centre. These bricks are so built together as to form a number of parallel flues through which the waste gases of the furnace pass on their way to the chimney, and by means of the ribs, transverse flues, through which the air passes in order to be heated. These air flues are

joined together on either side of the gas flues by longitudinal flues. Whilst the air to be heated is introduced into the lowest of the heating flues and flows alternately left and right through the horizontal transverse flues in an upward direction, finally reaching the combustion chamber through special flues, the waste gases enter their respective upper rows and work downwards, thus making use of the principle of counter currents. In this way the waste gases of combustion in consequence of the very great surface of the thin walls dividing the air from the waste-gas flues are used to the utmost, and the incoming air is heated to a correspondingly high degree. The special firebricks are rebated at the ends to prevent leakages in the recuperators, and by this means a mixing of the air with the waste gases of combustion is rendered practically impossible.

As an analogy to the methods of regeneration and recuperation of waste heat, the two methods of supplying water from a tank may be taken. The first method, that of supplying water from a tank under a diminishing head, is analogous to the reversing checkerwork system of regeneration; for with the water, the pressure gradually diminishes as the level drops, and likewise the preheated air or gas gradually decreases in temperature from the time of reversal until the next time of reversal. The second method, that of supplying water under a constant head, is analogous to the recuperative system, for there are no great changes in pressure in the case of the water or temperature in the case of the recuperative system.

The physical properties of the materials used in the construction of regenerators and recuperators have received extremely little attention, and the scientific principles involved have never been clearly enumerated. The materials for both regenerator checkerwork and recuperator brickwork must be sufficiently refractory to withstand the highest temperatures to which they will be subjected, and should have a low coefficient of expansion, as great and constant changes in volume are bad for the life of this part of the furnace. The efficiency of these portions of furnaces will depend on quite different phenomena: for example, the materials for reversing regenerators must have a high specific heat, as it is essential that the checker-brickwork should be able to absorb and hold the heat from the waste gases; also it is necessary to have a material with high diffusivity for heat, because, on reversal, the hot brickwork must give up its heat readily to the cold air passing through, and the chambers as a whole must have a high thermal capacity. It is a somewhat difficult matter to reduce to formulæ these desirable qualities in the materials, and to decide definitely the quantitative proportions in which the physical properties should be present, as some of the properties have quite an opposite effect on the ultimate qualities desired; e.g., the thermal capacity is equal to the multiple of the weight of material and the specific heat, or $w \times s$, and this may be reduced to $v \times d \times s$, where v is the volume and d the density. On the other hand, the diffusivity varies directly as the conductivity and inversely as the volume specific

heat, being represented by the formula $\frac{k}{sd}$; it will be seen that, in order to keep this diffusivity high, it will be necessary to have a material of high conductivity. On examining the formulæ for heat capacity and for diffusivity, it will be seen that the density will tend to increase the heat capacity, but, at the same time, to decrease the diffusivity of the materials.

Under these circumstances it is probably better to use a material of high diffusivity, since the thermal capacity can be regulated by size. It will be seen that, theoretically, it is possible to use a material of such high conductivity and low specific heat that the diffusivity would be so high as to necessitate a too frequent reversal unless the chambers were excessively large; and, on the other hand, it would be possible to use material of such high specific heat and density, and such low conductivity, that the checkerwork would not take the heat from the waste gases or preheat the incoming air at all efficiently. The material for regenerators should also be fairly porous.

In the case of the brickwork for recuperators, by far the most important property is conductivity, and this should be as high as possible. The other important points are total area of surface and thickness of material through which the heat has to travel. The transference of heat may be represented by the equation $Q = kA \left(\frac{t_1 - t_2}{x} \right)$, in which Q is the quantity of heat transferred, A is the area, t_1 is the temperature of the hot gas at any one point in the flues of the recuperator, and t_2 the temperature of the air at a point adjacent, and x is the thickness of refractory material through which the heat has to travel. This formula does not entirely represent the truth, as the temperature changes from point to point along the system; it is, however, near enough for the present purpose. It may be added here that the total quantity of heat transferred may be approximately represented by the formula $Q = M \times (T - t) \times s$, where M = mass of gas passing per unit of time, T the temperature of the gases leaving the furnace and entering the recuperator, t the temperature of the gases leaving the recuperator and entering the chimney, and s the specific heat of the gases. In the case of recuperator brickwork, the questions of specific heat and diffusivity are only of secondary importance, as they only come into play at the very commencement of using the recuperator, that is, in the initial heating up. From this point of view it is desirable that the material has a low specific heat, as it is necessary to have a high diffusivity and not at all necessary for it to be able to retain heat. In designing recuperators it is necessary to have sufficient surface to extract most of the heat from the waste gases and to transfer it to the incoming air, and another important point is the distance through which the heat has to pass; and thus it is necessary to make the walls of the flues as thin as possible, due regard being given to strength. The bricks should also be made as dense as possible.

From a heat transference point of view, it may be considered that metal recuperators would be good, and in certain directions these have been used, as, for instance, in the first types of hot blast stoves, but the great objections to metal include oxidation and expansion and contraction on heating and cooling.

The advantages claimed by the advocates of the two systems are as follows:—

I.—ADVANTAGES OF THE REGENERATIVE SYSTEM.

(1) A much more efficient absorption of the heat in the products of combustion, and therefore the heating of the incoming air to a higher temperature.

(2) A considerable economy in coal resulting from the better absorption of the waste heat, and the better return of that absorbed heat to the incoming air.

(3) A much cooler chimney flue and chimney.

(4) Owing to the reversible flame, the brickwork of the regenerators is refreshed and cannot become overheated as in the case of the flame travelling always in one direction.

(5) The inevitable thin and weak walls forming the recuperators of the furnace on the continuous counter current system are quite avoided. Hence, not only the loss by more frequent repairs is avoided, but also the loss in fuel due to the leakage of the incoming air through the joints of these thin walls soon after the furnace has been set to work.

(6) A higher temperature is obtainable in the regenerative gas furnace with reversible flame, due to the hotter air available for combustion.

(7) In many operations, the possibility of considerably increasing the temperature for a short time by reversing the gas and air is found to be of great value.

(8) The regenerative furnace has been proved to be very successful in the case of large furnaces requiring high temperatures, as in the case of the open hearth furnaces.

II.—ADVANTAGES OF THE RECUPERATIVE SYSTEM.

(1) No reversing valves needed, this saves considerable first cost and also saves troublesome and costly repairs and manual labour in working the furnace.

(2) Small size of the recuperators, and therefore reduced cost of building.

(3) The flues of the recuperator are easily accessible, and can, if necessary, be cleaned whilst the furnace is working.

(4) Great compactness of the whole structure.

(5) No great and frequent changes in the temperature of the recuperator part of the furnace as in regenerators.

(6) Owing to the large and efficient heating surface of the recuperator bricks, a great saving in fuel is effected, especially over ordinary coal-fired furnaces.

(7) The secondary air passing through the recuperators in very thin layers is heated to a high temperature, and the combustion in the furnace is complete.

(8) The great advantage which can be claimed for recuperative furnaces over regenerative furnaces is undoubtedly that the principle can be applied with very beneficial results to small furnaces, such as hardening muffle furnaces, all types of small annealing and reheating furnaces, etc. Furnaces to which it would be almost absurd to apply reversing regenerative chambers may be readily fitted with recuperative flues and worked with as little, or even less labour than open-fired furnaces.

THE ELECTRO-SATURATION OF FATTY COMPOUNDS WITH HYDROGEN.

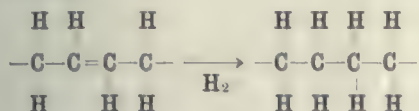
By ERIC K. RIDEAL.

THERE are two cases in the whole range of industrial chemistry in which the practical and technical details have by far outstripped those scientific and theoretical investigations which are usually the framework of industrial enterprise; these are the conversion of the unsaturated fatty acids into saturated ones, and the so-called "cracking" of oils.

With the ever increasing demands for soaps and butter substitutes the problem of using vegetable oils in addition

to animal and vegetable fats has become one of great importance. The solution of the problem is to be found in some method which will reduce the iodine value of the oil by means of the addition of hydrogen. The acids of the oils and fats only differ from one another in the fact that, while the former contain one or more doubly-linked carbon atoms in the carbon chain, the latter contain no such linkings, and are represented by the simple formula $\text{CH}_3(\text{CH}_2)_n\text{COOH}$.

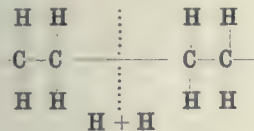
Thus the reaction in question may be represented diagrammatically by the rupture of a double bond by means of hydrogen:—



The hydrogen in this case is generally supplied from an external source.

The rapid growth in motor traction on the land and sea and in the air has resulted in a corresponding increase in fuel for internal combustion engines.

New sources of burning oil of a low flash-point are being sought for, and the conversion of oils of high flash-point, as well as shale oil and coal oil, into suitable fuel is one of the greatest problems which is facing us at the present time. In the case of the cracking of high-flash-point oil the oil itself may be a mixture of the higher homologous paraffins of the series $\text{C}_n\text{H}_{2n+2}$. When these are heated to a high temperature partial decomposition occurs, and a product is obtained which consists of a mixture of lower homologues of the series $\text{C}_n\text{H}_{2n+2}$ together with some olefines, C_nH_{2n} , and other unsaturated hydrocarbons. We may view this as the splitting of a long carbon chain in one or more places by means of heat and the subsequent addition of hydrogen:—



the hydrogen being obtained by means of the conversion of a saturated hydrocarbon into an unsaturated one.

If the oil to be "cracked" is a benzene derivative, containing one, two or more aromatic nuclei, with or without aliphatic side chains of varying lengths, the problem is the same, namely, the addition of hydrogen in order either to break a single bond or to loose a double one between two neighbouring carbon atoms.

The hydrogen in this case is generally not separately produced, but is derived from some of the hydrocarbon already present. There seems to be no reason why good yields should not be obtained by the treatment of oils in a similar manner to that used for the reduction of the unsaturated fatty acids.

The simplest method of bringing about such reductions is by means of heat alone. The heating may be carried out under normal or high pressures. An unexplained point is to be noticed in the distillation of coal. At low temperature distillations, chiefly saturated paraffins, together with some other aliphatic hydrocarbons, are obtained, while at higher temperatures the main product consists of benzene and aromatic aliphatic hydrocarbons. A possible explanation of the fact may be that at the higher temperature the coal reduces the paraffins to unsaturated hydrocarbons, which then in their turn form closed ring compounds (poly-

methylene derivatives) of which the benzene derivatives are the most stable.

At the present time the most valuable method we possess for reduction, especially for the reduction of the unsaturated fatty acids, is the direct catalytic method.

This may be accomplished while the acid is either still liquid or when vaporised.

By the action of a current of hydrogen on solutions of olive, castor, cotton-seed, cod-liver, or linseed oil, which contain colloidal palladium in suspension, products may be obtained whose iodine values are approximately zero.

The practical difficulty of recovering the colloidal palladium from the reduced acid limits the application of the process. In ethereal solution colloidal platinum and hydrogen gas will bring about the reduction of oleic to stearic acid, but the method is open to the same objection as the former one.

Several methods of heating fats in autoclaves under pressure in a current of hydrogen have been worked out. Finely-divided iron, copper and nickel, which have been formed by the gradual reduction of the hydroxides of these metals in an atmosphere of hydrogen, appear to be the most efficient catalysts. Even the hydrides of these metals have been suggested as suitable contact materials, very efficient reduction being said to take place when oleic and similar unsaturated acids are heated under pressure with cobaltic hydride.

Instead of using hydrogen as a reducing agent the possibility of bringing about the change by means of formaldehyde and similar reducers has been proposed. A somewhat ingenious method consists in passing the oil vaporised with steam over a red-hot iron plate. The iron not only partly reduces the steam to hydrogen with the formation of oxide of iron, but at the same time it acts as a catalyst. These methods are in general applicable to the formation of the paraffins and of the fatty acids.

In addition to the purely chemical catalytic methods we find the electrolytic ones, usually carried out in acid solutions. These should, all other things being equal, be more efficient than the purely chemical method. For here the hydrogen is being generated *in situ*, and should be capable of being more economically utilised than in the previous cases, where, under the conditions of reduction a great deal of hydrogen plays no rôle in the reaction whatever.

The two most important series of reactions to be investigated are those that take place at the electrode surface and those that occur in the interior of the electrolyte itself.

As far as investigations that have already been carried out seem to indicate, it is probable that those reactions taking place at the electrode surface are the most important; hardly any action occurring in the body of the electrolyte.

The influence of the cathode material is most marked, the best reduction occurring when the cathodes consist of those metals which easily form hydrides, such as palladium and the platinum metals, together with nickel, cobalt and copper.

It has also been found effective to increase the active area of the electrode by coating it with spongy metal, especially nickel, palladium and platinum.

The use of titanium salts in solution has been suggested as a method of increasing the yield of reduced acid.

It appears from these various experiments that the hydrogen when liberated "*in statu nascenti*" has not much effect on the unsaturated hydrocarbon or fatty acid, but that these are only reduced by being brought in contact

with an unstable hydride of some metal. Further investigation is needed to prove or disprove this assumption.

This method is not directly applicable to the hydrocarbons, since they are not electrolytes and are not soluble in ionising media, but it is possible that the desired reduction might be accomplished by means of fine emulsions in some suitable electrolyte.

An interesting electro-chemical method for the reduction of the unsaturated fatty acids is to be found in the treatment of the oleic or other acid in films. When these are subjected to the influence of the silent electric discharge in the presence of hydrogen under reduced pressure the tendency towards saturation increases. The almost general rule is that substances tend to polymerise under the influence of the silent discharge; in this case saturation is not brought about by polymerisation, but by means of the addition of hydrogen.

Data as to the efficiency of nearly all these processes are not yet forthcoming.

CURRENT LEGAL TOPICS.

By WILLIAM JAGO, F.I.C., F.C.S.

THE Merchandise Marks Acts have served a useful purpose in the way in which they have prevented the offering for sale, or the sale of goods, with a false trade description. The operative clause of the Act of 1887 provides, *inter alia*, that:—

"(1) Every person who . . . applies any false trade description to goods . . . shall subject to the provisions of this Act, and unless he proves that he acted without intent to defraud, be guilty of an offence against this Act.

"(2) Every person who sells, or exposes for, or has in his possession for, sale, . . . any goods or things to which any . . . false trade description is applied . . . shall, unless he proves that having taken all reasonable precautions . . . he had . . . no reason to suspect the genuineness of the . . . trade description; . . . or that otherwise he had acted innocently; be guilty of an offence against this Act."

Proceedings have been recently instituted under this Act by the Board of Trade, at the instance of the Silk Association of Great Britain and Ireland, against certain dealers for selling goods under the names of "Sylkrep," "Tussah. Sylkmerv," and "Orient Art Silk" fabrics, no silk being used in their manufacture. In all cases the magistrate convicted and imposed fines in varying amount. In a considered judgment the stipendiary, Mr. C. M. Atkinson, dealt with the question of whether these admittedly trade descriptions were or were not false. Silk he regarded as meaning the material woven from certain delicate soft threads or fibrous substances produced by certain insects, among which are the mulberry silk-worm, or

closely allied species, such as certain oak-feeding worms. The fabrics which formed the subject-matter of the prosecution were freely admitted to be material wholly composed of vegetable fibres, and obviously, therefore, not silk in the sense of being a product of insect secretion.

In the case of "Orient Art Silk," the contention of the defence was that the word "silk" was qualified by the adjective "art," and that "art" is a contraction for "artificial." The magistrate pointed out, however, that the word commences with a capital A, and with no full stop after "t." While, therefore, he regarded it as proved that "art. silk" was an accepted contraction for "artificial silk," the words "Art Silk" he viewed as indicating a fabric made of silk, the texture or design of which was of an artistic character. He therefore regarded the use of this term as suggesting a "trade description" which constituted a breach of the Act. In the case of "art. silk," which he considered to be misleading, he mentioned that it had been largely employed by many persons, not only without any intention to defraud in the ordinary sense, but without any sinister motive or improper design whatsoever.

In the case of "Sylkrep" and "Tussah Sylkmerv," the magistrate viewed the word "silk" as spelled with a "y" instead of an "i," as necessarily having the same sound as "silk." He therefore considered it to imply a fabric made of silk. Further, "Tussah" being a description of a variety of silk, this served to enhance the suggestion of silk. Again, he decided that the defendants had brought themselves within the provisions of the Act, and had used a false trade description. He, however, indicated that he regarded the advertisements of "a new fabric, 'Sylkmerv,' permanent lustre," offered at a price of 8½d. a yard, as showing that "there had been no intention to cheat or defraud the public in the ordinary sense." This brings the sale very nearly within the proviso of the Act which exempts anyone who had "acted innocently," and no doubt accounts for the very light penalty which was inflicted.

It may be of interest to refer here to the interpretation of the law governing the use of invented words as trade marks, and, as a consequence, trade descriptions, since a permissible trade mark is also evidently a permissible trade description by the person who is the owner of the trade mark. As an example of a word dealing with a closely allied topic to that of "silk" and "silk," some observations of Lord Herschell in *The Satinine* case are of interest. He lays down the rule that, if the word be an invented one, the *quantum* of invention is not at all material. The underlying principle is that the registration of an invented word is permitted because it "deprives no member of the community of the rights which he possesses to use the existing vocabulary as he pleases." Again, no mere variation of the orthography or termination of a word would be sufficient to constitute an invented word, *if to the eye or ear the same idea would be conveyed as by the word in its ordinary form*. Evidently "silk" could not be regarded as permissible. The word

must be clearly and substantially different from any word in ordinary and common use. Summing up the result of the cases, a mere ordinary addition to, or mis-spelling, or variation of, a word in use in the English language does not make the word so formed an invented word.

So far as "silk" is a trade description, there are four classes of fabrics to which the word, either with or without qualification, may be applied, viz. :—

(1) Silk derived from the filament wound round itself by the silk-worm, *Bombyx mori*, in forming its chrysalis.

(2) Silk secreted by other silk-producing worms, as the Tussah worm, *Antheraea mylitta*.

(3) Artificial silk, consisting of nitro-cellulose or analogous material forced during solution through apertures, or otherwise, so as to form a fibre on drying off.

(4) Imitation silk, consisting of vegetable or other fibres, so treated as to give them an appearance resembling silk.

The first of these being silk proper, no question arises as to the propriety of applying the word "silk" without any qualification whatever.

In the case of the second class, the material is again formed by an insect fibre secretion, and has every claim to be regarded as silk, though here the qualifying adjective "Tussah" might well be used as a sub-division of silk proper.

The third group of substances is, from the present point of view, much the most interesting. So long as the artificial product differs materially from natural silk, whether in chemical composition, physical properties, or appearance, so long must it be clearly distinguished by a name indicating its artificial origin. The question, however, arises: What is required when artificial silk becomes identical with the natural product? If the chemist succeeds in exactly reproducing the silk-worm secretion, and the engineer devises a machine by which it is formed into precisely the same type of fibre as ejected from the spinnerets of the silk-worm, then, is this product, or is it not, entitled to be called "silk"? The question is important, because the number of natural products which will be in the future produced artificially and synthetically is sure to increase. To take another example; alcohol, of which at one time the only known method of production was that of fermentation, can now be produced synthetically. If synthetic alcohol is offered as a commercial product, need the qualifying adjective be used, or may it be called "alcohol" only? Very closely allied to this problem is that of the improvement of any article by removing a commercially injurious ingredient, and so making it identical with a higher quality of the same article. It has thereby been said to have been caused to "simulate" the higher quality. But if the removal has in fact transformed the lower into the higher grade, then surely any name descriptive of quality may with justice be applied to the improved article. This, however, can scarcely be said to include descriptions of origin or source, since these, though often indicative of quality, are not necessarily so in all cases. Probably

the best way of solving the problem in each particular instance is to remember that the prohibition applies to a "false trade description." If, for purposes of trade, the description is misleading, then an offence has been committed. Thus, if the artificial article is identical in chemical composition and physical properties with the natural one to such an extent as to be indistinguishable for trade purposes, then, in most cases, the general name without qualification may be properly adopted. Thus, synthetic alcohol of the same degree of purity as that produced by fermentation might quite well be described as alcohol, since for the purposes of trade no distinction could exist. But there is an important exception where the source of origin has in itself a trade value. The writer has been informed by a diamond expert that selected Cape stones are indistinguishable from Brazilian diamonds. Nevertheless, because of their origin, Brazil stones command a higher price, and it would be a false trade description to call an equally good Cape diamond a Brazil stone. In these matters source of origin, irrespective of quality, has often a distinct trade value; and where such is the case the description must not be misleading. The point is rendered all the more difficult because names of origin may lose their primary meaning, and become simply indicative of quality, in which case the secondary meaning may be the real trade description. As instances of disputes of this kind may be mentioned those of "Witney" blankets and "What is a sardine?" The touchstone is: What does the description mean in the mind of the trade and the public? So long as "silk" means to them a material prepared from a particular insect secretion, then it must not be applied to any other body. When the word comes to mean a material of certain character, however prepared, then "silk" may be regarded as including both natural and artificial varieties. For some time yet, however, it is fair to prophesy that silk will continue to mean the natural product, and the artificial article must be so described.

Obviously the fourth group, consisting of what are simply imitations, can have no claim to the description of "silk."

The Council of the Royal Society of Arts has awarded the Society's silver medal to the following readers of papers during the session 1912—1913: Dr. F. Mollwo Perkin, "Natural and Synthetic Rubber"; Mr. Joseph Pennell, "The Pictorial Possibilities of Work"; Mr. Henry J. Wilson, "The Education and Employment of the Blind"; Mr. E. Russell Burdon, "The Development of Research Work in Forest Products"; Mr. Frank Bailey, "Electric Supply in London"; Mr. Walter C. Hancock, "The Physical Properties of Clay"; Mr. H. V. Lanchester, "The Design and Architectural Treatment of the Shop"; Mr. F. O. Ogilvie, "The Science Museum"; and Mr. Axel Welin, "Life-saving at Sea."

At the Assembly of Faculties held on July 2nd at University College, Professor G. D. Thane (Dean of the Faculty of Medical Sciences) said that Sir William Ramsay had presented £500 for the purchase of chemical library books and periodicals.

MOLECULAR PHYSICS.

By J. A. CROWTHER, M.A. (Fellow of St. John's College, and Demonstrator in Physics in the Cavendish Laboratory, Cambridge.)

CHAPTER V. (*continued*).

THE NATURE AND SIZE OF AN ELECTRON.

WE have seen that the electrical mass of a charge e for moderate speeds is equal to $\frac{2}{3} \frac{e^2}{a}$ where a is the radius of the space occupied by the charge. The mass of an electron is 8.8×10^{-28} gms., while the value of the charge it carries is 1.57×10^{-20} units. Substituting these values in the formula we find that the radius of an electron is 1.87×10^{-13} cms.

We have stated elsewhere that the radius of an atom is of the order of 10^{-8} cms., and have attempted to form some idea of the exceeding smallness of this magnitude. We may now say that small as the atom is, the electron is so much smaller that the electron bears to the atom which contains it very much the same relation as a pea to a cathedral.

We have seen that the whole of the mass of the electron is due to the charge which it carries. The thought at once suggests itself: Are there indeed two kinds of mass or is all mass electrical in its origin? Probably most physicists cherish this belief at the bottom of their hearts, but it cannot at present be said to be much more than a pious hope. The mass of a negative electron is about $\frac{1}{1700}$ part of the mass of a hydrogen atom. Neglecting the positive charge of the atom, of which we know practically nothing, it would require 1,700 electrons to make up the mass of a single hydrogen atom. This of course is not *a priori* an impossible number considering the smallness of the electron; and speculations along these lines were for a time freely indulged in. In this case, however, experiment failed to confirm the bold conjecture. The number of electrons in the atom has been determined at any rate approximately, and affords no support for such a theory.

As this number is one of considerable theoretical importance, we may perhaps be allowed to describe, very briefly, one of the methods by which attempts have been made to determine it. Consider a single electron flying through a sheet of metal. With the huge velocity which it possesses a sheet of aluminium, say $\frac{1}{4}$ th mm. thick, is not a very serious obstacle to a β -particle. Neglecting for a moment the positive charge which keeps the atom together, the various atoms which our particle encounters must present to the particle the appearance of a series of large chambers, empty save for a certain number of particles, minute in comparison with the atom, and similar to itself.

At a considerable distance these fixed electrons will have little effect on the moving corpuscle. If, however, in its flight it approaches one of them closely it will be repelled, as the two particles each

carry a negative charge. The nearer it approaches the greater will be the repulsion, and the further the moving particle will be deflected from its original path. We may call this a collision. It is, in fact the same sort of collision as we imagine to take place between two gas molecules. The direction in which the particle will be deflected will be perfectly arbitrary, and a second collision may actually undo the work of the first. On the whole, however, the greater the number of collisions the greater will be the deflection, and it is not beyond the possibilities of mathematics to determine the most probable effect of a given number of these deflections. The problem is indeed mathematically equivalent to the well-known theorem of the drunkard's walk. Suppose a drunkard walks so many yards before falling down, and after each fall, having lost all sense of locality, sets out again in some new and arbitrary direction, at what distance from his starting point will he be most likely to be found after a given number of falls? This problem, under a somewhat different title, has been solved by Lord Rayleigh in that marvellous compendium of mathematical physics, the Theory of Sound.

If then we can find experimentally the most probable deflection of a β -particle after passing through a certain thickness of solid matter, we can deduce the number of collisions it has made in its passage through the solid, and hence the number of electrons in unit volume of the substance. Since the number of atoms per cubic centimetre of any substance can readily be deduced from the data given in Chapter III., the number of electrons in each atom can at once be determined.

A series of experiments upon these lines was recently performed by the author. By various experimental devices, which it would take us too far from our course to describe, the mean angle through which an originally parallel pencil of β -rays was scattered in passing through sheets of various substances was determined. By experimenting on sheets of different thicknesses the author was able to show that the mathematical treatment outlined above was applicable to this particular case, and hence to deduce the number of electrons in the atoms of the various elements experimented upon.

The matter is, perhaps, hardly so simple as we have described it. We have neglected so far the effect of the positive electrification which we know must be present in the atom if the latter is to be electrically neutral. This will exert a certain attraction on the flying electrons.

Unfortunately, we are not yet acquainted with the nature of positive electricity. Professor Sir J. J. Thomson's experiments on the positive rays, brilliant as they have been, have not at present thrown much light upon this exceedingly difficult

problem. For the present the term "positive electrification" remains for the physicist very much what the term "catalytic action" is for the chemist—a not too humiliating method of confessing ignorance. If we suppose that the positive electricity is distributed uniformly over a sphere the size of the atom (a hypothesis which lends itself very readily to mathematical treatment), the author's result would indicate that the number of electrons in an atom is almost exactly three times its atomic weight. That is to say, the number of electrons in a hydrogen atom would be three. If we go to the other extreme, and suppose that the positive electrification is a sort of nucleus at the centre of the atom, and that the electrons revolve round it somewhat after the manner of the rings of Saturn, the number of electrons in a hydrogen atom works out at unity, the number in any other atom being equal to its atomic weight. The assigning of unit atomic weight to hydrogen would then have a very definite physical significance, as it would be the lightest atom which could possibly exist. In either case the number of electrons in an atom is only a very small multiple of its atomic weight. We cannot, therefore, assign any appreciable fraction of the mass of the atoms to the negative electrons it contains.

There still remains, of course, the possibility that the mass is electrical, but that it resides in the positive portion of the atom. If the formula for the electric mass be examined, it will be seen that for a given charge the mass is inversely proportional to the radius of the sphere upon which it is concentrated. If we suppose that the positive charge on the hydrogen atom to be concentrated upon a sphere only $\frac{1}{1700}$ of the size of the negative electron, its mass would be 1,700 times as great, that is to say, equal to that of the hydrogen atom. Our perfect ignorance of the nature of positive electricity renders the suggestion not untenable, though evidence for it is sadly lacking. For the present our belief in the electromagnetic nature of all mass remains an expression of our faith that all the varied phenomena with which we have to deal are manifestations of some single principle or essence which underlies them all. In what way future experiment will realise our belief in the present instance remains to be seen.

CHAPTER VI.

THE CHEMISTRY OF THE MODEL ATOM.

WE have now learned all that is to be known about electrons, their nature, their mass, their charge, and their dimensions. We have seen that they form a part of all atoms, and have discovered, at any rate approximately, how many of them we may expect to find in an atom of any given element. We have seen also that electrons form a very minute part of the mass, and a still smaller part by volume of the whole atom.

It might be thought therefore that their influence in determining the properties of the atom would be proportionately small. There is much evidence however that this is not the case, as we shall have occasion to see during our further survey of molecular

physics. The electrons are small but they are mobile. It is entirely owing to this mobility that we are so well acquainted with their properties. It is owing to this same mobility that they exercise such a marked influence upon the chemical and physical character of the atom.

Our difficulties in constructing a satisfactory model of an atom lie, as we have already seen, in our almost complete ignorance of the nature of the residue of an atom from which the electrons have been extracted. The atom can lose at any rate some of its electrons without any serious change of properties, and as the normal atom is neutral, the residues after extracting the electrons must possess positive electrification. Beyond this we know little or nothing.

Three views are possible. In the first place we may assume of our residues what the earlier atomists assumed of their atoms, that they are fundamentally different in character, that copper is copper, and tin is tin, and that there is no more to be said about it. This would be to abandon all hope of attaining any explanation of those recurring similarities between the properties of the different elements which are so clearly brought out in that greatest of the generalisations of descriptive chemistry, the periodic classification of the elements. This is a policy of despair.

Assuming, then, that the remainder of all the atoms is composed of different amounts of the same stuff, call it matter or positive electrification as we will, this substance may be either continuous or divided up into larger or smaller particles. The fact that the α -particles given out by all radioactive substances are identical might suggest that these particles are the stones from which the edifice of the atom is built up. The α -particle is, however, too complex a structure to serve as a protyle; it is, for example, four times as heavy as our lightest atom, and, in all probability contains at least two electrons. Professor Nicholson has built up an interesting chemical system from protyle atoms of atomic weight, 1, 2, 3, and 4, but these in themselves would in all probability be complicated structures, and in the absence of further evidence on which to work it seems better to proceed at once to the fundamentals.

The existence of a positive electron is not quite beyond the realms of possibility. It may be that there is some sort of undetected one-sidedness about our experiments which accounts for our complete failure to observe it. If at any time it makes its appearance, it is possible that something of the argument which follows may have to be referred to the positive rather than to the negative electron.

Taking all the facts into consideration, the most probable hypothesis at the present moment is the one which regards the positive part of the atom as forming either a uniform sphere, coterminous with the atom, or a dense nucleus at its centre. In the first hypothesis the electrons would move about within the positive sphere and would be attracted with a force varying directly as their distance from the centre of the sphere. On the second

hypothesis some, at any rate, of the electrons would be outside the positive charge and revolve as satellites around it, like the rings round the planet Saturn being attracted to it in this case, with a force varying inversely as the square of the distance.

The latter suggestion has very much to recommend it, but it has also the very great defect from our immediate point of view that it does not lend itself at all readily to mathematical treatment. In other words we cannot easily determine from the laws governing such a system the way in which the electrons would be arranged, and hence we cannot easily deduce the properties to be expected in such an atom. It is most probable that the arrangement of the electrons in the two cases would exhibit the same general features, though, of course, the actual values in any given case would be different. As it is not at all likely that either of these simple systems will eventually be found adequate to represent the atom of any real substance, we may, without any loss of generality, confine our attention to the simpler case.

The grouping of a number of electrons in a sphere of positive electrification which is just sufficient to neutralise their charges at points outside the sphere, has been investigated theoretically by Professor Sir J. J. Thomson. A single electron if at rest will place itself at the centre of the sphere, or if in motion will describe a circle around that point with a radius depending on its velocity. Two electrons would occupy the opposite ends of the diameter of a circle whose radius is equal to half the radius of the positive sphere while three electrons would arrange themselves at the points of an equilateral triangle. The arrangement of four electrons at the corners of a square is, however, not a stable grouping if the ring of electrons is at rest, but becomes possible if they are revolving round the centre with a speed which exceeds a certain critical value. If their velocity falls below this the system collapses into a tetrahedron with the evolution of energy.

The determination of the arrangement of any number of electrons in a space of three dimensions becomes at first difficult and finally impossible. A few cases have, however, been worked out. Thus six electrons would arrange themselves at the corners of a regular octahedron, but, on the other hand, the arrangement of eight at the corners of a cube is not stable and will collapse into two tetrahedra, one inside the other, unless we station at least one other electron within it. We are thus brought face to face with one of the most important generalisations in electron grouping, namely, that it is quite impossible for any system to make a large display of electrons near its surface without a corresponding stock within. The presence of a given number of electrons near the outside of the atom demands that there shall be a certain definite number of electrons within in order for the system to be stable. To use a commercial metaphor, atom cannot have all its goods in the shop window. Otherwise there will be inevitable collapse into some less pretentious system.

(To be continued.)

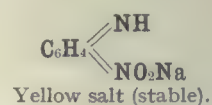
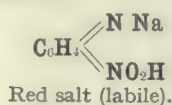
NOTES ON RECENT THEORY AND PRACTICE.

By HERBERT H. HODGSON, M.A., B.Sc., PH.D.

COLOUR chemistry is ever the active field for constitutional speculation, and is always furnishing a rich supply of new methods for attacking chemical problems. In this regard Green and Rowe have made a valuable study of the quinonoid salts of the nitroanilines. They establish the existence of ortho-nitroanilines of the benzene series in alkaline solution, in the form of salts of the quinonoid type

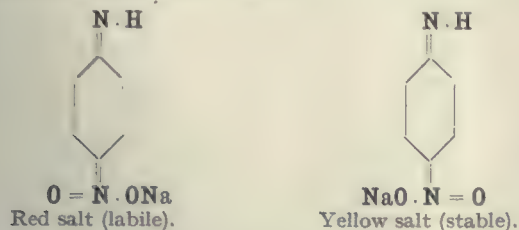
$\text{R} = \text{NO}_2\text{M}'$. For purposes of isolation as well as for studying the mechanism involved, a number of ortho, meta, and para nitroamines were treated in benzene solution with sodium ethoxide. Deeply coloured salts appeared in the case of all primary and secondary ortho and para nitroamines, but no such quinonoid change occurred with meta compounds; also when both hydrogen atoms of the amino group were replaced by alkyl radicles no salts could be obtained. This absence of reaction in the meta series is noteworthy, in view of the still open question as to the existence of meta-quinonoid compounds. The salts are characterised by great instability, necessitating rapid analytical operations and water-free solvents. They form deep yellow, orange or red powders insoluble in benzene, but hydrolysed immediately by water to the parent amine, liberating free alkali hydroxide. On the latter fact was based their mode of analysis, a weighed amount being treated with water, and, after filtering off the precipitated amine, the alkaline filtrate titrated with standard sulphuric acid and methyl-orange in the usual way. In every case the results corresponded closely with those required for a monosodium or monopotassium salt of the

quinonoid nitronic acid, $\text{R} \begin{smallmatrix} \text{NH} \\ \text{NO}_2\text{H} \end{smallmatrix}$. The case of para nitroaniline was particularly interesting, as two differently coloured sodium salts were obtained according to the conditions employed. When p-nitroaniline was in excess a red salt was the stable form, but as soon as the benzene solution became alkaline it changed to a yellow and more stable variety. If, however, p-nitroaniline was replaced by its monoethyl derivative, only one salt was found to exist corresponding to the yellow salt above. This observation tends to support the possibility of constitutional isomerism in the sense of the formulæ:—



In view of the fact, however, that a disodium salt of p-nitroaniline, $\text{C}_6\text{H}_4 \begin{smallmatrix} \text{N Na} \\ \text{NO}_2\text{Na} \end{smallmatrix}$, could not be obtained by employing a large excess of sodium ethoxide, and that similar pairs of coloured isomerides were found by Hantzsch in the nitro-

phenol salts, and by Sudborough and Picton in the free picrylarylamines, the isomerism would appear to be of the type termed by Hantzsch "chromo-isomerism," and possibly due to a difference in stercal configuration, thus:—



The influence of halogen substitution on the shade and usefulness of some dyes has been systematically studied by Weber. He finds that when *o*, *m*, and *p*, chloro, bromo, and iodo-anilines are diazotised and coupled in the usual way with α -naphthol-8-sulphonic acid, yellow to red dyes are produced, the para compounds being darker and the meta lighter than the ortho members, whilst the shades deepen from chlorine to iodine. Redder shades are given with α -naphthol . 2 : 8 disulphonic acid, the same generalisations holding good. The dyes are faster than the unsubstituted analogues, while their colouring power is much enhanced. The ortho- and para-compounds are more valuable than the meta, and the bromo and iodo derivatives are much more effective than the chloro dyes.

The part played by the solvent during the course of a chemical reaction has been studied by Salkowski, who has established the disturbing effect of alcohol on many reactions. When half a volume of alcohol is added to a potassium iodide solution to which chloroform, a few drops of sulphuric acid, and a solution of nitrite are also added, instead of the characteristic violet colour being formed in the chloroform layer after shaking, an orange or reddish-yellow coloration is obtained. A similar disturbing effect has been noted in the case of methyl or amyl-alcohol, ethyl acetate, and acetone. Even the characteristic blue colour obtained by adding ferric chloride to phenol, is changed to a dirty green or yellow by the presence of alcohol.

A novel method for resolving externally compensated amines has been recently introduced by Pope and Read. Pasteur's method was to crystallise with an optically active acid, a method greatly extended by the use of the active camphorsulphonic acids introduced by Pope and Peachey. This method, however, frequently proves unavailing, owing either to the formation of partly racemic compounds or to unfavourable solubility relations between the two salts produced. A new and useful idea was introduced by E. Erlenmeyer, Jun., which consisted in condensing the amine with the aldehyde *d*-helicin, and separating the *d*-helicin derivatives formed from the *d*- and the *l*-base by fractional crystallisation. The authors have shown that the condensation products from *d*- and *l*-oxymethylene camphor and a primary or secondary externally compensated amine, can be used for ascertaining

whether the amine in question is externally compensated or potentially optically inactive; in the former case two condensation products are obtained, one containing the residue of the *d*- and the other of the *l*-base, in the latter case only one acidic amide results. The condensation product may be quantitatively decomposed by titration in alcoholic solution with bromine, yielding bromo-oxymethylene camphor and the hydrobromide of the amine.

The hydrolytic action of water on the ammonium salts of organic acids has accounted for the fact that very few have been prepared, and in the case of most dibasic acids only the ammonium hydrogen salts have been obtained. Keiser and McMaster find that normal salts may readily be prepared by passing dry ammonia into a solution of the organic acid in ether, alcohol, or both, when the salts separate as white precipitates.

For preparing amides and substituted amides, Hofmann's classical method of heating the ammonium salts of carboxylic acids with primary and secondary amines has fallen into disuse owing to its supposed disadvantages. Now Deaker finds that the method is simple and convenient, provided the best temperature is obtained and retained to the end of the reaction. The latter is the temperature at which water is eliminated, it may be slowly, from the salt, whilst the dissociation is still hardly appreciable.

The use of the less common organic acids for the separation of the rare earths is further extended by Whittemore and James, who find that yttrium and lanthanum may be quantitatively separated from the alkali metals by precipitation with ammonium sebacate, while cacodylic acid may be employed for separating neodymium, samarium and gadolinium.

A new and delicate test for oxygen is proposed by Binder and Weinland, who make use of the fact that deep-red solutions are formed when ferric salts and catechol are mixed in alkaline solution. If ferrous sulphate replace the ferric salt, then no immediate coloration is observed, but, owing to the rapid absorption of oxygen from the air, the red colour appears after an interval. Since this test is exceedingly delicate, the authors being able to detect oxygen in the carbon dioxide used for the estimation of nitrogen by Dumas's method, the alkaline solution of ferrous sulphate and catechol may be used in the Hempel pipette for the quantitative absorption of oxygen in gas analysis. Vigorous shaking is a necessary manipulation, however.

With the advent of acetylene welding, the question of solvents for acetylene has become of commercial importance. James finds that those organic liquids containing the carbonyl group are generally the best solvents. Organic acids, however, must be excluded, since the hydroxyl in the carboxyl group apparently inhibits the solvent action of the carbonyl. The presence of the latter group does not of itself account for the solubility, since methylal and acetal are very good solvents. James finds that acetaldehyde fulfils all the industrial requirements for an acetylene solvent.

THE HISTORICAL MEDICAL MUSEUM.

By CECIL H. CRIBB, B.Sc. (LOND.), F.I.C.

It is frequently urged, and not without justification, that the chemist in this country pays but scant attention to the historical side of his science. Except in rare cases, like that of the late J. Campbell Brown, it is not made the subject of lectures, still less of examinations, and the mass of facts and theories the student has to assimilate during his academic career leaves him little time for things of no immediate practical value. So, too, the man in active practice has enough to do to keep himself *au courant* with the latest developments of his particular branch of work, and the teacher, under the thralldom of the examination system, has as a rule to turn a blind eye to what would be a fascinating field of research. Under these circumstances it is not unnatural that but few specimens of the apparatus and appliances used by early workers has survived to the present day. Much of what remains has been relegated to the lumber-rooms and cellars of the old universities and colleges, or is locked up in private collections and rarely sees the light. Much has probably gone to America, where the universities are already alive to the value and interest attaching to scientific "antiques," while it is only necessary to scan the catalogues of some of the Continental book and print dealers to realise that there is, on the other side of the Channel, a steady demand for old engravings, pictures and books dealing with the early history of the physical sciences, of which evidence is not found in similar publications here.

The "Historical Medical Museum," at 54a, Wigmore Street, organised by Mr. H. S. Wellcome in connection with the Seventeenth International Congress of Medicine, which meets in London this month, will do much to stimulate interest in these matters, and those who visit it will be surprised at the number of rare and curious objects which have been brought together for the first time.

As the title implies, the exhibition embraces objects of historical interest connected with medicine and the sciences. There are few of the latter which have not been called into the service of medicine, but, as would be expected, surgery and pharmacy, perhaps more correctly described as "arts," are, the most strongly represented.

In the short space at our disposal it is impossible to do more than indicate the wide scope of the collections, and to give some idea of the nature of those exhibits which appeal to the chemist in particular.

Broadly speaking, the exhibits may be classified under the following headings: Works of art, books, manuscripts, ancient diplomas, etc., apparatus and appliances of every kind connected with early science, reproductions of ancient laboratories, hospitals, pharmacies, etc., early photographs, X-ray photographs and apparatus, instruments of torture, and rare and curious *materia medica*.

The fact that the descriptive guide, which makes no attempt to be a complete catalogue, runs to 140 pages will give some notion of the magnitude of the collection. Leaving on one side the purely medical and surgical exhibits, and the hundreds of oil paintings and engravings relating to these subjects, there are still a vast number of objects connected with chemistry, or with pharmacy, from which chemistry to a large extent developed.

There are some 500 mortars, with and without pestles, of stone, ivory, bronze and other metals, dating from 3,000 years ago to the last century, on many of which beauty of design has been lavished with a free hand.

There is an excellent collection of microscopes, although

some of the very earliest forms are not represented, and scores of medicine chests, some of great historical interest, such as that used by the Duke of Wellington during his campaign in the Peninsula and that of Nelson which accompanied him on the *Victory*.

Of ancient glass work, alembics, retorts, etc., such as were used by the alchemists, there is, considering its rarity and the natural reluctance of most owners to let it go out of their possession, a considerable assortment. Scales and weights and steelyards, from all over the world, and dating from the seventeenth to the nineteenth century, also show the fine craftsmanship expended on articles of everyday use in days of greater leisure than our own.

Indeed, the ancient apparatus taken as a whole forms a striking object lesson to the modern manufacturer of scientific instruments, even the simplest pieces showing that blend of beauty and fitness for its work in which many of our modern productions are so woefully lacking. The forms of and patterns on the mortars, the mouldings on the wooden apparatus, the graceful forms of some of the microscopes, the superb workmanship of the medicine chests, and the patterns and colours of the pharmacy jars make them things of pure delight.

Engravings and paintings of alchemists and their laboratories are so numerous that it has been impossible, up to the present, to catalogue them, and only want of space has prevented the collection being more complete.

Finally, the reproductions of old laboratories, pharmacies and hospitals, with life-sized figures, though somewhat suggesting Madame Tussauds', enable us to realise, in a manner otherwise impossible, the crude and primitive apparatus with which the pioneers of science had to work, and the interest is heightened by the fact that much of it, including furnaces, alembics, flasks and bottles, are not models, but have actually survived from the middle-ages.

PERSONAL AND OTHER NOTES.

It is announced that a scheme has been devised by the Advisory Committee to the Board of Education in connection with the Exchequer grants to the Universities and Colleges in England, for the superannuation of Professors and other members of the teaching staffs of the newer universities.

Owing to the resignation of Professor H. R. Procter from the Chair of Applied Chemistry (chemistry of leather manufacture) at Leeds University, Dr. Stiasny has been appointed to that post.

Dr. W. C. McCullagh Lewis has been appointed to the Chair of Physical Chemistry in the University of Liverpool.

Dr. Paul Haas has been appointed Demonstrator in Applied Chemistry at University College, London.

Mr. C. W. Dyson Perrins has offered to subscribe £5,000 towards the new chemical laboratory at Oxford, if such a sum is required in excess of the £15,000 granted from the University Endowment Fund.

NOTES ON CHEMICAL ENGINEERING.

By J. W. HINCHLEY, A.R.S.M., WH.Sc.

CHAPTER II. (*continued.*)

SIFTING.

THE length of travel in all screening operations should be such as to provide, at least, the theoretical number of sifting actions for the size of particles, depth of bed, and character of screen in question. The amount of undersize in the oversize material after sifting varies enormously. In many industries 20% is considered excellent, and much larger figures are common.

In the mining industry, the preliminary sizing by sifting is often a preliminary operation before treatment by wet methods for separation according to specific gravity; but in most chemical work, the oversize is simply removed for further grinding, and it is an economic question which determines the amount of undersize present in the oversize or "returns" which is desirable.

CHAPTER III.

SIZE SEPARATION BY FLUID MEDIA.

THE cost of sifting, on account of the wear and tear of plant and the slowness of the operation, together with the fact that fine sifting is always unsatisfactory, has compelled technical men to look for other methods of accomplishing the object in view.

In the mining industry where the separation of materials of different specific gravity constitutes a large portion of its activities, these other methods find their greatest development. By the use of currents of water or air, separation of particles, according to their specific gravity and size, can be accomplished with more or less practical efficiency. Where, as in the treatment of ores, the difference in specific gravity of the particles is the important consideration, a sifting process usually precedes the separation by fluid currents. The same process may, however, be used to separate by size, particles of the same material.

It has been noted that by agitating a granular material on a horizontal surface the larger particles rise to the top of the bed and the smaller travel to the bottom; if, however, a current of water be driven upwards or forced in a series of pulsations through the bed, the reverse action will occur and the smaller particles will rise to the upper layer. If the water flows in both directions the action is more complicated and the small particles may travel downward if the interstices in the larger material are large enough. In the operation of "jigging," which is based on these facts, the material is supported upon a screen while currents of water are produced in the bed formed, either by the up-and-down movement of

the screen or by the action of pistons on the water itself. In a typical jig (Fig. 37) the material is fed on to one end of a fixed sieve A, where it is subjected to pulsations of water produced by the plunger B, and by the time it has travelled to the other end is separated into layers; the upper layer slides over the inclined shoot C and the lower layer passes under this shoot and over the adjustable sluice-gate D. The water is supplied by the trough E and passes through the valve F at each pulsation. Usually such jigs are placed in a row, the same material passing over the sieves of each in turn. Generally, also, the fine heavy material passes through the sieve into the hutch G, and is removed at intervals. The shape of the hutch has a considerable influence on the action of the machine, and most machines are made of the shape shown. Such methods of size separation are rarely employed in chemical work, but a method of separation called elutriation or washing, which consists in taking advantage of the

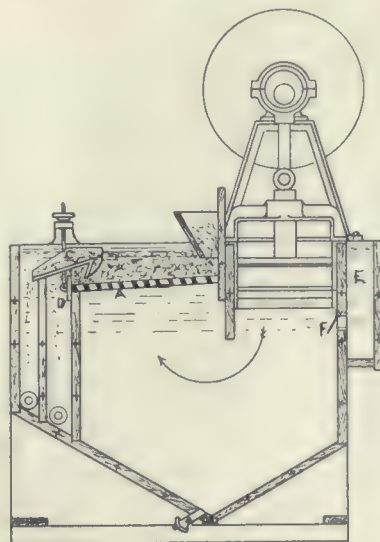


FIG. 37.—TYPICAL JIG.

different rates of settlement in water of different sizes of material is common. After levigation or fine grinding in water and in the case of many natural materials—clays, steatite, barytes, graphite, starch, etc.—this process is most useful.

In this operation, as still carried out in many factories where small quantities of very finely divided material are required, the substance is stirred or ground with water, run into a vat, and allowed to stand for a few minutes. The pulp above a certain distance from the bottom of the vat is then run into settling tanks where it may stand for several hours or days for complete settlement. The clear liquid is syphoned or run off and the sludge

removed to suitable drying or other plant. In the case of the finest clays, a week or even a month may be taken for settling, but with most materials the operation is complete in three or four hours.

For large outputs, and where the time of settlement is not too great, long troughs in series are used through which a continuous and carefully regulated flow of pulp is allowed to pass. These troughs may be from 50 to 100 ft. long and the slope about 1 to 2 ins. in 100 ft. Any very light material such as woody matter does not deposit, while the coarse particles settle near the entrance to the trough and the finest near the weir at the exit.

Such plants are very cumbersome, and many attempts have been made to produce compact machines for dealing with such problems efficiently.

The most satisfactory methods depend on the use of centrifugal machines, by means of which a force of settlement can be produced which is much greater than that due to gravity alone. In Gee's apparatus (Fig. 38) the liquid carrying the suspended particles is passed

through a tube driven at a high speed by the pulley B and provided with radial divisions driven by the pulley A at the same speed so that the liquid moves with it. The suspended matter deposits on the lining of the tube, and, after the operation, is removed in cakes, in which the fineness of the particles varies from one end to the other. By cutting the cakes transversely the material is divided into different qualities according to the degree of fineness. The separated material can also be removed as a thick pulp by driving pulley A alone.

Where, however, comparatively coarse material is to be removed from fine material the Freygang elutriating plant (Fig. 39) is probably more convenient. The tube A, mounted on trunnions for adjustment, contains a screw conveyor which continually lifts the material which is fed into the hopper B. Water is also fed into this hopper at a definite rate and overflows at C carrying with it suspended particles, the fineness of which depend on the rate of flow of the water and the speed of the conveyor. The large size material is discharged above the water line in the apparatus at the spout D. For closer separation several such apparatus may be used in series.

The operation of this type of plant may be

theoretically considered and compared with the facts of practice. When a particle falls in a liquid it encounters a resistance to its motion which depends on the velocity acquired and which causes it rapidly to assume a constant velocity. With very small particles and consequently low velocities, the resist-

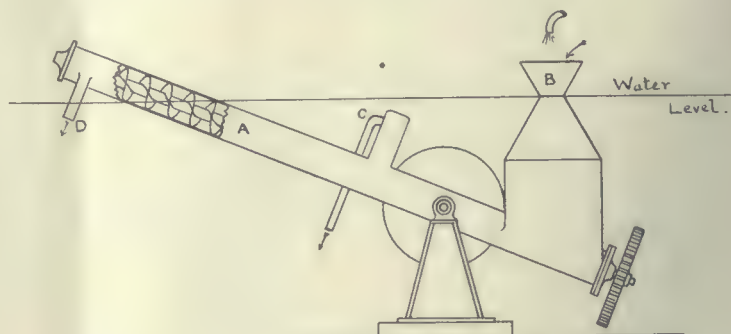


FIG. 39.—FREYGANG'S ELUTRIATOR.

ance is mainly due to the viscosity of the liquid and Stokes' law is closely followed—

$$V = \frac{1}{18} g D^2 \left(\frac{d - d'}{\eta} \right)$$

where all dimensions are in C.G.S. units.

D = the diameter of the spherical particle.

d = density of the particle.

d' = density of the liquid.

g = Gravity constant.

η = viscosity of the liquid (for water at 20° C. η = .010).

The velocity is therefore proportional to the square of the diameter of the particle and the difference between the specific gravities of the particle and the fluid. The critical size of particles above which the law fails is approximately .008 in. for sand in water, the critical velocity being about 1 in. per second. For heavier materials the critical size would be less and the critical velocity somewhat greater.

Above this critical velocity the formation of

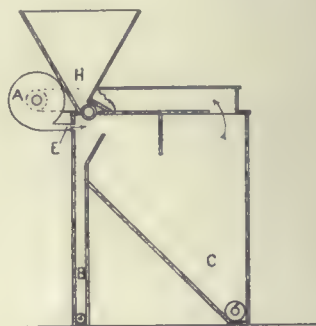


FIG. 40.—DRY SEPARATOR.

eddies changes the character of the resistance until it becomes approximately proportional to the square of the velocity, and the velocity acquired is pro-

portional to the square root of the diameter of the particle,

or
$$V = K\sqrt{(d-d')D}$$

where K is a constant depending on the units employed. Using C.G.S. units as before the value of K for sand in water is 27.5.

These generalisations, which state the facts, approximately, for particles falling freely or under "free settling conditions" need some correction to represent the practical conditions in which mutual interference between the particles takes place or under "hindered settling conditions."

A simple correction which meets the extreme case is obtained by substituting the average density of the fluid and the particles for that of the fluid in the formulæ given. In actual practice the results

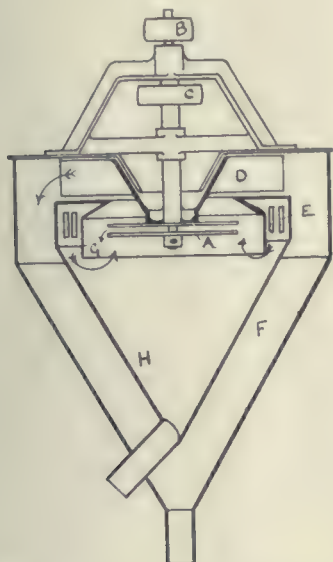


FIG. 41.—CYLINDRICAL SEPARATOR.

lie somewhere between free settling and hindered settling conditions.

Wet methods of size-separation are often undesirable, and in many cases dry separation is essential. By the use of currents of air instead of water, dry separation with very finely-divided material can be accomplished, but when the separation is required to be close the results are not so satisfactory as with wet methods.

A simple plant for dry separation is shown in Fig. 40. The material is fed at a regular rate into the hopper H , and falling, meets a horizontal jet of air from the slit A ; the coarser material falls into the chamber B , the fine passes into the chamber C , and is removed by the worm D . The fan E circulates the same air continuously so that the finest dust is not discharged into the atmosphere. The maximum difference of pressure in such apparatus is about 12 ins. of water column, and a number of similar jets vertically arranged are often employed. It is obvious that perfect adjust-

ment of the feed and absolutely even running of the fan are essentials to success. By fixing the fan centrally and arranging the other parts in cylindrical form a very compact form of the apparatus (Fig. 41) is obtained. This type is used in large numbers in place of screens. The material falls on to the feeding plate A , which is rotated by the pulley B . The lower part of the hopper is rotated by the pulley C , and carries the fan D . The relative speeds and the distance apart of the base of the hopper and the feeder plate can be adjusted to suit the material. The smaller particles are carried forward by the current of air produced, through the slits E into the chamber F , while the large particles strike the cylinder G and fall into H .

A similar arrangement of parts is often provided in dry grinding plant, the current of air removing the material from the grinding zone and returning the large after being separated from the small, which in this case is the finished product.

The principle of the jig has also been applied for the size separation of materials, but since the mass action of the particles conflict with their action in the jig, such machines are only suitable for separating according to specific gravity, and then only when water is unavailable. This failure may also be anticipated from theoretical considerations. The motion of the particle may be expressed by the equation

$$AD^3d \frac{dv}{dt} = AD^3(d - d')g - BD^2V^n$$

where A and B are constant and represents time. At the instant of the commencement of motion, i.e., when $V=0$, it will be seen that $\frac{dv}{dt} = \left(\frac{d-d'}{d}\right)g$ or, that the acceleration is mainly determined by the density rather than by the size of the particle.

(To be continued.)

BISMUTH: ITS ORES, IMPURITIES, USES, AND SOURCES OF SUPPLY.

BISMUTH in appearance approximates to antimony, but has a foliated texture; in colour it is a silver white lustrous metal with a specific gravity of 9.83; it melts at 518° F. Bismuth has the peculiarity whilst cooling of expanding about 2.3% in volume; advantage is taken of this property in the preparation of alloys useful in the arts, some of which are used for the production of stereotype plates. It has the additional peculiarity when in the molten state, that it can be cooled 10° F. below its solidifying point and still retain its liquid form, but the temperature rises when the metal solidifies. Bismuth, when exposed to moisture, becomes coated with a reddish powder, but dry air produces no effect on it. The yellow oxide Bi_2O_3 is formed when the metal is heated in air to a red heat, it then burns with a bluish flame. In comparison with silver the thermal conductivity of bismuth is extremely low, less than as two to a hundred. Useful fusible alloys can be made from the metal due to its low melting point; for this purpose tin, cadmium and lead are used in varying proportions. The melting points range from 140° F. to 201° F. By combining two parts of bismuth with one each of tin and lead, an alloy is produced melting at 201° F.

Another alloy melting at the same temperature is obtained by combining bismuth, tin and lead in the proportions 20, 30 and 50. An alloy melting at the very low temperature of 140°F . results from combining bismuth, tin, cadmium and lead in the proportions 50, 13, 10, 27. An intermediate alloy can be made melting at 150°F . to 158°F . by combining the same metals in the proportions 50, 14, 12, 24. By reducing the proportion of tin used and adding cadmium, the melting point of the alloy is reduced. Another use for which bismuth can be made available is in the preparation of an amalgam in combination with mercury, occasionally used for the silvering of mirrors; lead and tin are sometimes added. Anti-friction metals contain about $\frac{1}{4}\%$ of bismuth, and electric fuses are made of bismuth, cadmium, lead and tin in the proportions 50, 15, 20 and 21; one part each of bismuth and lead to two of tin, make a solder used in some trades. The oxide Bi_2O_3 is also useful as a colour for porcelain and glass.

Bismuth has been known as far back as the fifteenth century, and it was described in the sixteenth century by Agricola. One of the peculiar qualities of bismuth is its diamagnetic property, that is, it is repelled by the poles of a strong magnet. A bar of bismuth balanced between the two poles of a horseshoe electromagnet adjusts itself parallel to the two poles and not diagonally as other metals. It is one of the poorest metallic heat conductors found, and appears rarely as oxide. Bismuthenite has been found combined with chalcocite in the Daniel Mine in Wittichen, in the Black Forest, and was given the name Wittichenite.

Minerals containing bismuth are of rare occurrence, and the supply is limited; very few localities are known where the quantity is sufficiently large to be profitably worked; the percentage of bismuth in the ores is generally too small to enable it to be worked for itself alone; the ores are composite and are worked for several products, one of them being bismuth. Workable bismuth ores contain the following minerals:—bismuthinite, bismite, bismutite, bismutospharite, pucherite, uranopharite, guanajuatite and tetradymite; among these are bismuth uranate, b. selenide, b. telluride; there are also many double sulphides containing lead, copper and silver. Gold and bismuth form a natural alloy, the composition of which corresponds to the formula Au_2Bi ; in this form it occurs in the Maldon district of Victoria, Australia, as a maldonite. In Chile, in the San Antonio mines, Potrero Grande, near Copiapo, bismuth is soft combined with silver in the form of Chilenite. Both the above may be described as rare minerals and of no economic importance; they will not, so far as the exposures are at present known, add to the supply of bismuth ore. Native bismuth is a greyish-black heavy mineral, which shows a white metallic lustre with a somewhat pinkish tinge when it is broken up; it frequently contains traces of arsenic, sulphur, tellurium and other elements. It is brittle and sectile, with a specific gravity varying from 9.6 to 9.8. A rare mineral containing about 90% of bismuth, is bismutite, a hydrated bismuth carbonate, with a specific gravity of 7 to 7.5, and a hardness ranging from 4 to 4.5. This mineral is soft and readily crushed, with a colour varying from white to yellow. Pucherite is a bismuth vanadate of a reddish-brown colour, mostly found in Saxony, and guanajuatite is a bismuth-selenide named after its place of origin, Guanajuato, Mexico.

Another mineral is bismuth ochre Bi_2O_3 , also known as bismite, with a specific gravity of about 4.4, containing a very large percentage of bismuth; it is of a grey to yellowish-white colour and frequently occurs foliated. These minerals which all contain 80 to 90% of the metal, only occur in

small quantities, the ores actually worked rarely contain as much as 15%, more usually only 10%. Another form also containing 90% of bismuth is bismutospharite, a carbonate, found in spherical form with a concentric and radiating structure. Its hardness varies from 3 to 3.5, and its specific gravity from 7.3 to 7.6. In colour it ranges from bright yellow to dark gray, or dark brown. Bismuth sulphide Bi_2S_3 , is an interesting mineral containing 81% of the metal, with a specific gravity of 6.5 and a hardness of 2, with a gray streak. Its colour is lead gray. It crystallises in the orthorhombic system and is both sectile and fusible. These ores occur in the palæozoic rocks; the gneisses, granites and other igneous rocks, as well as some slates, are intersected by quartz and pegmatite veins; it is among the latter the bismuth ores should be looked for; they often contain a great variety of minerals, including iron and copper pyrites, cobalt and nickel sulphides, barytes, hematite, zinc blende, galena and very occasionally, gold, silver and antimony.

The most important bismuth producing centres are Australia, Bolivia and Peru; in the crude form the constituents are as follows:—

—	Australia.	Bolivia.	Peru.
Bismuth ..	96.2	99.05	93.30
Antimony ..	0.8	0.56	4.57
Copper ..	0.5	0.26	2.06
Lead ..	2.1	—	—
Residue ..	0.4	0.13	0.07
	100.0	100.00	100.00

The countries producing bismuth include Bolivia, Peru, the United States, Tasmania, Saxony, where it is obtained from lead and silver ores in the form of oxides, together with litharge.

Bismuth ores have been found in North Queensland, Australia, in the Herberton district, about 17°S . some twenty-five miles in a westerly direction from that township between it and Mount Garnet, and about fifty miles from the coast. The outcrop was first worked in 1905, but the mineral which attracted attention at that time was wolfram. Bismuth occurred as a carbonate. Four years later the miners exploited the workings for the bismuth ore, which also contained specks of metallic bismuth; the wolfram, which apparently was never very plentiful, became a secondary product. The ore was hand-dressed, with jigs, and sold as concentrates. The surrounding country is biotite granite, the biotite being plainly indicated. The lodes, or veins, are 9 to 12 ins. thick and appear to form very flat saucer-like basins; there are probably a series of them; the workings opened out between 1905 and 1909, outcropped above a small watercourse, borings in the surrounding area would be necessary to ascertain whether other lodes occur below. The gangue of the veins is nearly all topaz, and innumerable small crystals of topaz occur, and these with carbonate of bismuth, specks of metallic bismuth, and a little wolfram constitute the veins. Bulk samples of ore after being picked and ready for crushing, contain 7 to 11% bismuth and 1 to 4% wolfram. The production of bismuth in the United States remains quite stationary from year to year. No systematic effort has ever been made to mine bismuth and the element produced mainly continues to be gained as a by-product in the treatment of gold, silver and lead ores. From Colorado and New Mexico some high-grade bismuth ores have been

treated, but the production from this source makes but a small portion of the production of bismuth for the year. The bismuth market is mainly retained in the hands of an English company and the Government of Saxony, which practically have a monopoly of the business, operating or controlling the sources of bismuth and maintaining prices at a level wherein considerable profit must necessarily be made. The bismuth produced in the United States from year to year is mainly a by-product in electrolytic lead refining at works in the town Graselli, Indiana. This bismuth is the result of the refining of bullion made from the treatment of lead ores obtained from Bingham Junction, Utah. The entire bismuth production of the United States averages annually 70 to 80,000 lbs. There are a number of mines in the United States in which bismuth forms a percentage of the metallic contents of the ore, but few of such ores are rich enough in bismuth to warrant the extraction of the metal. Bismuth has been found also in Colorado, New Mexico, Montana and Nevada. It is extremely likely that it occurs in quantity in Mexico, but former attempts there to mine ore for its bismuth contents have not been financially successful. The whole of the bismuth produced in the United States is consumed there, and there is, in addition, a very considerable importation reaching about 200,000 lbs. annually. The price of the metal has for some years risen, it is now over 8s. per lb.; four years ago it was only 6s. 3d. Its two main uses in America are for medical preparations, and in the manufacture of low-fusing alloys for service in the fire automatic extinguishing devices now so generally found in textile factories, warehouses and stores.

Bolivia occupies a very prominent position among the very few bismuth-producing countries. It is exploited there with other metals, from which its separation is easy. It is found in the mineral zone between Huayna-Potosi in La Paz and Chorolque in Potosi; the principal region is that of Tazna. The Huayna-Potosi Mine is noted for having produced the largest single masses of native bismuth ever made. Single masses of native bismuth weighing almost two tons have been taken out, and the native material is distributed throughout the mine. Native bismuth is rarely found in the crystalline shape, it is more generally massive. When first found its colour is a reddish silver-white, but it tarnishes quickly.

To obtain refined bismuth the concentrated ore passes through processes of roasting, smelting and refining. The first process has for one of its objects the volatilisation of the arsenic and antimony contained in the ores. Those containing these constituents, as well as sulphur, are crushed so as to pass through a sieve having four meshes to the linear inch; they are then roasted with carbon. This process is preferably performed in a long hearth, reverberatory furnace, as heap or kiln roasting—is not applicable to bismuth ores. The best form of furnace is one with a hearth 16 ft. by 9 ft., in which six to seven tons of ore can be dealt with daily. The ore has to be kept well shaken to prevent it agglomerating, the contained arsenic, antimony and sulphur are thus gradually got rid of. The second process is smelting, for which crucibles or reverberatory furnaces are required. Owing to the readily volatile character of bismuth, the charge must be of a very fusible character, and usually contains 10 to 20% of sodium carbonate, also oxide of iron, lime, old slag and coke or charcoal in proper proportions. The contents of the furnace are in due course rendered fluid and are then run off into iron moulds; a slag solidifies on the top of these moulds, the bismuth below retaining its heat and remaining fluid

can be run off through tap holes at the bottom of the moulds. The metal is then in a crude form, combined with any lead, gold, silver, copper, or other constituent of the original ore. Any contained copper generally forms a *matte* with some of the bismuth, and any nickel and cobalt present in the original ore, form a *speiss*, which also contains some bismuth. Other smelting processes are also in use, one known as a wet process, of which there are several varieties, consists of heating the crushed ore in earthenware pans with strong hydrochloric acid; the solution is then filtered from the insoluble gangue. The solution is diluted with a large excess of water, which precipitates the bismuth in the form of an oxychloride, from which the metal can be readily obtained. Meymac in France is one of the places where the smelting of bismuth ores is carried on.

The bismuth resulting from one or other of these preliminary processes has then to be submitted to a final refining process, after which it is ready for use. A process similar to that employed for refining lead is resorted to, as the metal has such a slight affinity for oxygen. The crude bismuth is heated to melting point and exposed to the influence of atmospheric oxygen, by which means all impurities are removed and practically pure bismuth obtained; averaging 99.86%. The remaining 0.14% of impurities generally consist of copper, lead, sulphur and silver, and possibly mere traces of some other metals.

ENGINEERING NOTES.

By R. J. DUNDERDALE, B.A. (CAMB.), A.M.I.C.E.

Determination of Moisture in Coal.

Towards the end of May a paper was read on this subject before the Institution of Mining and Metallurgy.

The object of the paper was to point out some of the more obvious sources of error occurring in the more usual methods of coal moisture estimation, and to suggest an improved method.

This improved method depended on the use of an apparatus as follows: A 100 c.c. flask in a beaker connected to a U tube containing quicklime, which was further connected to a sulphuric acid drying tube. The coal was placed in the flask, and the latter surrounded by boiling water; the U tube was placed in a beaker containing a boiling aqueous solution of calcium chloride.

The action and purpose of the apparatus is obvious, and the claim, that only the moisture from the coal is retained by the quicklime, while any other volatile matter present will not combine with this material. The method and apparatus seem almost ideal if the last point mentioned above be realised—but that point seems somewhat doubtful. The method should, however, lead to as accurate, or more accurate, results than any at present in use.

The certain and exact estimation of the water in coal by a works laboratory, or, indeed, by any method, will probably always be a source of very great difficulty; but if this method, or one of the older ones, was carefully standardised and performed, there would then be a pretty sure comparative guide to the moisture contained in any sample of coal.

In the above method the coal is probably powdered before introduction to the flask, and thus will certainly be introduced a moisture error equal to about 1% of the total weight of the sample tested.

The Future of British Fuel.

Under the above and other similar titles articles keep appearing from time to time in the *Times Engineering Supplement* and other engineering publications, discussing the conservation and uses of our coal and oil supply, and the possible modifications of the uses of these fuels, so that they may be more economically carbonised in the first instance, and the by-products and results of the primary carbonisation rendered more remunerative and useful.

The time when such points as those brought forward in the articles referred to needed to be pressed home on the consideration of chemists and engineers is now well past, but there still remains a considerable difficulty in the way of using, say, coke for most processes in engineering works.

From an engineering point of view the drawbacks are as follows: (1) With the present make the market for coke allows of a price which makes it less economical than coal for steam raising purposes unit for unit. (2) Most furnaces are constructed with a view to burning coal, and in some cases very considerable modifications would have to be made to render them suitable for coke.

These difficulties can, and soon will, no doubt, be overcome, if there is present money in it. A more serious difficulty to overcome, and one which at present has a large effect, not only on our coal supply, but on the purity of our atmosphere, is the prejudice and somewhat middle-headed and selfish attitude of the average non-technical householder. Put shortly, their attitude is, (1) coal has a bright and cheerful appearance in a sitting-room fire (and we only burn 20 tons a year, so what does it matter?); and (2) nobody can cook with coke.

The answers are simple, but will probably take years to force home, unless a strong appeal is made to the pockets of householders burning much smaller quantities even than that mentioned. The answers, by the way, may as well be added, too: (1) it may be said that wood logs are aesthetically more beautiful and thermo-dynamically and economically less efficient—all of which should render them much more acceptable; and (2) is simply nonsense, as many people who previously held this still widely-accepted view found out during the great coal strike.

Chemists in Engineering Works.

An article appeared in the *Times Engineering Supplement* for May 7th, entitled "Engineering and Chemical Research: Need for Co-operation."

After stating that the younger universities are now turning out a large number of youths with chemical degrees, who (by inference) cannot all obtain a remunerative employment as teachers of this science, or as assistants in the various almost purely chemical factories in this country, the article goes on to say that there is ample scope for them as steel, copper, aluminium and electrical works' chemists.

The author of that article then unhappily damps the more or less cheering tone of the earlier half column by remarking that chemists are to blame for the present depressing position, because there are limitations to the sums which engineers are prepared to pay for chemical research.

This is not very logical in the first place, and, in the second, the larger and more enlightened works in this country and in Germany do seem prepared to pay relatively very large sums, if they really know what they want to get, and are determined to find out if they can get it.

Put very crudely, these young chemists will be, in a great number of cases, very lucky to get 40s. a week as

analysts, unless they show extraordinary ability, and are in the pay of an employer possessed of what Spencer called "intelligent selfishness."

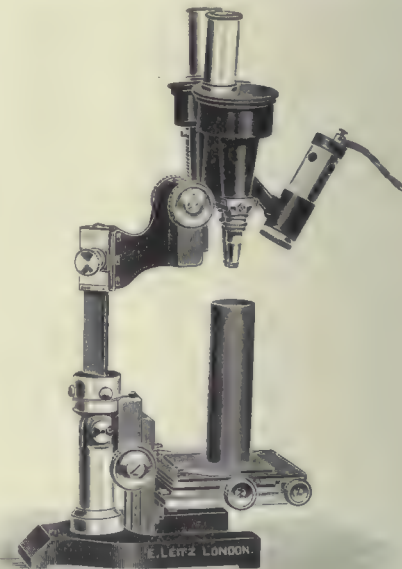
The author of the article mentioned then goes on to state that matters would be helped if these youths also received an elementary engineering training as well.

Speaking as an engineer with some chemical knowledge and experience, but not as a professional chemist, the present writer very much doubts if this is to be done, unless the period of purely unpaid training is to be extended to six or eight years, for certainly an engineer without influence cannot hope to command much more than £3 a week, after that period of training, purely as an engineer.

This condition will, we venture to think, continue for those who wish eventually to hold the higher positions in engineering factories employing chemists and in chemical factories employing engineers, and both for these men and those holding more junior positions the great hope for the future lies in the more enlightened and intelligent selfishness of the rising generation, for in the passing generation (outside the large firms mentioned) the number of senior engineers or chemists who know enough about the complementary branch is very limited, and, consequently, prices at present run low for a commodity which neither will trust himself to buy on his own knowledge and responsibility, *i.e.*, the work of one professing the other branch to his own.

A METALLURGICAL MICROSCOPE.

A VERY complete and substantially built stereoscopic binocular microscope, giving an erect and stereoscopic image, and possessing many desirable features, has just been completed by Leitz. This microscope has been constructed to embody the suggestions of a well-known and thoroughly experienced consulting metallurgist. It has been built to

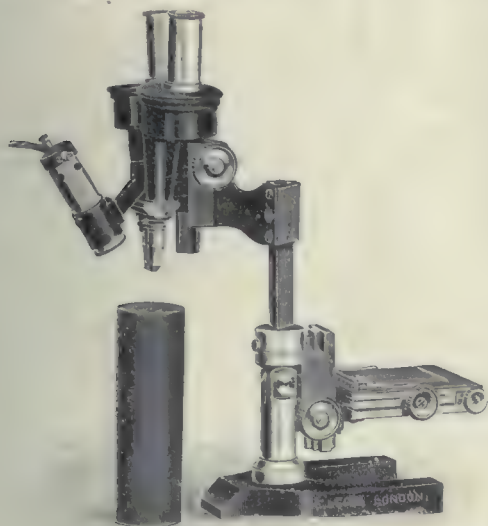


the specification and design of Mr. Wesley Lambert. The illustrations serve to show the chief features of this model.

The microscope proper is of the Greenough type. Two microscope tubes are so arranged as to bring the same object into focus in the axis of each tube. Each tube carries both an objective and ocular. The two objectives are mounted

on a single slide, and provision is made by a suitable adjusting arrangement to enable one to focus the object for each eye separately.

The stand comprises a heavy horse-shoe base of generous dimensions, carrying a substantial pillar to which the stage and body are fitted. The latter is considerably overhung, and is secured by an approved hinged joint, which permits the tilting of the instrument through an angle of 90 degs. By a simple slide joint, locked by a single



milled-head screw, the upper portion of the instrument may be detached and reversed. An examination is thereby possible of bulky specimens of too great a weight for the stage, or of such size that the microscope must be mounted above or placed upon them.

The stage is modelled upon the English pattern, and provided with anterior, posterior and lateral movements of considerable range. The surface plate upon the stage is removable and covers an opening.

THE IMPORTANCE OF VISCOSITY FOR THE STUDY OF THE COLLOIDAL STATE.¹

By WOLFGANG OSTWALD (Leipzig).

Every investigator who has worked, if only incidentally, at modern colloidal chemistry, knows the extraordinary variety of its phenomena, and the breadth of its laws, relations, and points of view. It is true, as a well-known physical chemist has said, that one approaches the centre of the earth wherever one may dig into it, that, in other words, the close study of any group of phenomena may lead to the most general laws. Nevertheless we know that there is a difference between different sets of phenomena, inasmuch as some may lead to important general results more rapidly and more directly than others. I may be permitted to choose as the principal subject of my contribution a statement of the reasons for this choice of subject and attempt to explain the significance of the experimental and theoretical study of viscosity for our knowledge of the colloidal state.

As the first point of view, which renders the study of the viscosity of colloidal systems so particularly interesting and important, I should mention *the enormous qualitative*

and quantitative variability of the viscosity of substances in the colloidal state. The range of phenomena is in itself extremely diversified and rich. We are accustomed to look on the viscosity of typical molecular dispersoids, such as a sugar or a salt solution, as defined by only two variables if we keep to the same dispersion medium. The viscosity of a molecular solution is in the present state of our knowledge defined completely by the concentration and the temperature. We are considering a system of only three variables, and can therefore plot strict viscosity-concentration curves at constant temperature, and viscosity-temperature curves at constant concentration.

The viscosity of colloids presents an entirely different case. If we take the simpler case of *suspensoid* colloids, *i.e.*, those systems in which the disperse phase still retains the properties of the solid state, at least *one* further variable of the viscosity enters into the matter, the size of the particles or degree of dispersity. It seems as if the maximum of viscosity appeared at medium values of dispersity, the question being for the present left open whether the size of the particles affects the viscosity directly or indirectly, *i.e.*, through the variable quantity of absorbed dispersion medium associated with it.²

A considerably greater number of variables, however, defines the viscosity of the *emulsoid* colloids, especially of those which become emulsoid through formation of solvates, such as gelatin, albuminsols, etc., also the cellulose and rubber sols, several lubricants, etc. In addition to the three variables: (1) concentration, (2) temperature, and (3) degree of dispersity, the following factors are already known experimentally to affect the viscosity of these systems:—

(4) Solvate formation: the viscosity increases parallel with the amount of dispersion medium taken up by the disperse phase.

(5) Electric charge or ionization. As has been shown by albumin sols, by E. Laqueur and O. Sackur and others, but especially by Wo. Pauli and his pupils, ionised albumin particles, which travel in the electric field, impart to the system a materially larger viscosity than uncharged particles. The influence of the electric charge on the viscosity of hydrated emulsoids is most closely connected with the influence of the degree of hydration; the two effects run parallel to each other at least in strongly dissociating media like water. I may dispense with a detailed discussion of this point, as the leading authority in this field, Professor Pauli, is dealing personally with these relations.³

(6) *The Previous Thermal Treatment.*—A gelatin sol which has been repeatedly warmed and cooled has, at least at first, a lower viscosity at the same temperature than a similar sol which has not been thus treated. On prolonged heating chemical changes, such as hydrolysis, frequently occur, which are *no longer reversible*, not even after prolonged standing.

(7) *The Previous Mechanical Treatment.*—A decrease in the viscosity of gelatin sols, and also of several dye-stuff solutions, can be produced by simply forcing the same

² See E. Hatschek, *Koll.-Zeitschr.*, 11, 280, 284 (1912).

³ It would be of great interest to ascertain if such a parallelism exists in feebly or non-ionising media, *e.g.*, in cellulose or rubber organosols. In this case a comparison between the dielectric constants and "dissolving or swelling capacity" on one hand, and between the viscosities of sols of equal concentrations in different media on the other, would be required. The possible influence of the variable charge on suspensoid colloids has likewise not received investigation so far. Theoretically such an influence is to be expected, as the magnetic field induced by the particle must act as a brake on its mobility.

¹ Delivered before the Faraday Society, March 12th, 1913.

several times through the viscometer, evidently an indication of a kind of "structure" even in such liquid sols. A special form of preliminary mechanical treatment is the mastication of solid colloids, *e.g.*, of rubber *before* dissolving. It is well known that samples of rubber thus treated give *less* viscous sols than untreated samples at the same temperature, concentration, etc.

(8) *Inoculation with Small Quantities of More Viscous Colloids.*—Small additions of viscous colloid after some time raise the viscosity of gelatin or dye-stuff solutions to an incomparably higher degree than would correspond to the increase in concentration due to the addition.

(9) *Time.*—The time factor, finally, is perhaps the most striking variable of the viscosity of hydrated colloids. In all determinations of the viscosity of typical examples of such colloids different values are obtained according to the *age* of the sol, according to the *velocity* with which, *e.g.*, the temperature is altered, etc. Generally speaking the viscosity *increases* with age and tends asymptotically to a final value. The age-viscosity curve appears in the most general case to be S-shaped.⁴ As regards the influence of the rate of temperature change and so forth, much more complicated relations appear to hold good. The alterations of viscosity with time are influenced by additions in the most varied manner.

If we mention in conclusion that (10) *additions* of both electrolytes and non-electrolytes may raise or depress viscosity in the most varied manner, that these effects in their turn depend strongly, both qualitatively and quantitatively, on the concentration of the additions, that with some additions suspensoid colloids also show distinct variations of viscosity with time, that there exist transitional systems with the most varied intermediate steps as regards viscosity, we certainly obtain the picture of an enormous *qualitative* diversity in the phenomena of viscosity in colloids. We are thus dealing with a group of phenomena large and interesting in itself.

The same thing, however, also holds good of the *quantitative* variations of the viscosity of colloidal systems. I would ask you to remember that a gelatin sol may, merely by altering temperature or concentration, or even by mere ageing, pass through all values of viscosity from that of water to that of a solid, as occurs in a process of gelatinising. For the viscosity of a colophony-turpentine sol, according to measurements by Glaser, the values between concentrations of 0 to 100% range from 1 to 10^{-20} . It is particularly remarkable, that such enormous changes of viscosity can occur even with *extremely small* ranges of temperature or concentration. Thus an agar sol between 0 and 1% concentration passes through all values of viscosity from one to several thousand. What is more, soap sols and certain complex organic compounds⁵ can attain the viscosities of solids at concentrations lower than 1%. Change of temperature has a similar marked effect, as shows itself, for instance, practically by the existence of "melting-points" and "setting-points." Thus the viscosity of colloidal solutions is distinguished by extreme variations as regards quantitative relations too.

In addition to the importance of viscosity phenomena as forming an extremely varied field for investigation, a further weighty consequence follows from the great variability just set forth; the determination of viscosity is a prominent *methodic principle* in investigating

the properties of the colloidal state, but especially in the study of those processes in colloidal systems which are usually described as *changes of state*. If it is desired to follow quantitatively the alterations of dispersity and of solvate formation, which are called peptisation, coagulation, gelatinisation, imbibition, etc., in principle any physico-chemical property of the system may be used as indicator of such changes. Practically, however, very considerable differences manifest themselves again between the various selected properties. Thus, for instance, the electric conductivity of a gelatin sol does not change materially during setting. Neither does ultra-microscopic observation permit us at present to follow this process quantitatively. The reason is that such properties either *do not vary sufficiently* during a given change of state, or that they are *not suitable for quantitative investigation*. That property of a colloid will, generally speaking, be best suited as an indicator which shows the largest possible variation with small changes in the colloidal condition, and on the other hand permits quantitative measurements, if possible by a method not too complicated. These requirements are eminently fulfilled by the viscosity. The extreme sensitiveness of this constant towards very small alterations in the condition of the colloid has already been described. On the other hand, you are, of course, aware that viscosity determinations, especially with the capillary viscometer are not too difficult.

The question now arises, in what way viscosity measurements can give information even on such changes as, *e.g.*, gelatinisation and swelling by imbibition, changes in which to some extent the properties of *solids* are involved. Closer investigation gives the important result, that in these processes the *concentration of the colloid*, while certainly playing some part quantitatively, does *not* essentially affect the qualitative character of the phenomena, which the viscosity of *dilute* colloids shows under the same experimental conditions. Thus Wilh. Ostwald and J. von Schroeder have first shown that spontaneous increase with time in the viscosity of dilute gelatin sols corresponds entirely with the setting of more concentrated sols. With increasing concentration the viscosity of the sols increases in increasing but entirely *continuous* ratio, until at certain concentrations or times it attains the values of a jelly, that is of a solid. The curves at different concentrations are throughout of the same character; additions also affect the viscosity of dilute sols and the setting of concentrated sols qualitatively in exactly similar ways.

Entirely analogous considerations apply to the study of swelling and imbibition phenomena. Although not much studied from this point of view, even liquid sols show such imbibition phenomena.⁶ Such are the absorption of water by gelatin and albumin sols, also by some dyes, which have been observed in osmometers and have been called "osmotic" or perhaps more correctly "pseudo-osmotic."⁷ Without entering into details, we may emphasise that the pseudo-osmotic imbibition of a gelatin sol corresponds most strikingly, on one hand with the swelling phenomena in the *solid* colloid, and on the other with the viscosity changes of the same colloid in suitable experimental conditions. The agreement between the phenomena of viscosity, gelatinisation, swelling, and pseudo-osmosis of such colloids is astonishingly complete down to details. The absolute acid concentration at which the first *minimum*

⁴ See Wo. Ostwald, *Grundr. d. Kolloidchemie*, 3rd ed., 1912, p. 191.

⁵ See, for instance, the papers by E. Hatschek, *Koll-Zeitschr.*, 11, 158 (1912); W. B. Hardy, *Proc. Roy. Soc., A*, 87, 29 (1912); B. Rossow and O. Doehle, *Koll-Zeitschr.*, 12, February, 1913.

⁶ Wo. Ostwald, *Grundr. d. Kolloidchemie*, 3rd ed., p. 312 sq.

⁷ The expression "pseudo-osmotic" is preferable, as these phenomena deviate in many ways quite considerably from the classical osmotic phenomena of molecular systems.

of swelling occurs for gelatin is the same as coincides with the corresponding *maximum* of viscosity; similarly the pseudo-osmotic pressure of sols varies, like the viscosity, with shaking, stirring, the thermal history, etc. In brief, we are dealing with a complex of phenomena most intimately connected with one another, which permits us to draw from one property far-reaching conclusions as to the behaviour of other properties.⁸ Among all these properties at present viscosity occupies a *central position*, as it is so far the most accessible and the most easily measured property.

Two further instances may perhaps be given showing the application of viscosity measurements to problems which have so far received little or no treatment from this point of view.

Here also the decrease in the viscosity of the suspension is at first entirely normal—possibly the extreme regularity deserves mention (the curve is a straight line). An astonishingly sharp change or break occurs between 57° and 58.5°, which leads to an equally remarkable steep increase, also in a straight line. Between about 65° and 75° the curve has a sharp bend and then continues, from 80° on, to rise exceedingly steeply. The curve only continues to 95°; it is, however, known that at still higher temperatures, say at 110° and 120°, the starch is transformed still further into its so-called *soluble* form. This is distinguished by *no longer gelatinising*, i.e., a solution treated at 120° is less viscous again than the same solution at about 90°. At still higher temperatures a *drop* in viscosity may therefore be anticipated, such as has been indicated by the arrow.

In yet another respect viscosity determinations appear to possess special importance as a methodic principle. The existing methods for measuring changes of state depend, with extremely few exceptions, on the determination of *points*. Peptisation, coagulation, setting and softening *points* have been determined, i.e., definite concentrations or temperatures, at which the process in question reaches a "perceptible" or "pronounced" value. The imperfection of this method is shown by experience; thus, for instance, coagulation points, i.e., temperatures, and concentrations differing among one another by 30 to 40% have sometimes been obtained. Of course, this does not amount to saying that such determinations of points may not occasionally lead to valuable results, but the method is not, in any case, an ideal one. The author has ere this tried to emphasise¹⁰ that these *static* methods for determining changes of state must be replaced by *kinetic* methods. The ideal case of a strict definition, e.g., of a coagulation, consists in establishing the *velocity equation* of the process, and then in characterising the effects of various coagulations and their concentrations by the numerical values of the *velocity constants*. It is only in quite recent times that such *kinetic* investigations and measurements have been applied to changes of colloidal state. We may refer to the work of H. Chick and C. J. Martin on the heat coagulation of albumin sols, H. Paine's investigations on the velocity of colloidal copper, etc. Viscosity is again to a high degree suitable as indicator property for such kinetic investigations, the more so as it does vary not only during the changes of hydrated emulsoids, but also during the coagulation of metal sols, as has been shown by H. W. Woudstra¹¹ among

others. Without doubt we have here still a large and fertile field for the application of viscosity measurements.

The author may be permitted to point out a third field, in which viscosity measurements promise to be of great value for the knowledge of the disperse state. As you are aware, modern colloidal chemistry has led to the fundamental conclusion that *continuous* transitions are possible between coarse suspensions, colloidal solutions, and systems of molecular dispersity. The first convincing experimental proof of this fact was furnished by H. Picton and S. E. Linder (as long as twenty years ago, in Sir William Ramsay's laboratory) with their well-known series of arsenic trisulphide sols. It was, however, only modern colloidal chemistry which drew the above conclusions from these and other important experiments and pointed out the advantage of studying rather the common features, and especially the *transitional phenomena*, instead of attempting unsuccessfully to draw sharp demarcations between the three classes.¹²

(To be continued.)

¹² *Koll.-Zeitschr.*, 1, 298, etc. (1907).

FINANCIAL NOTES.

At the ordinary general meeting of the Mond Nickel Company, Ltd., the Chairman stated that the balance to the credit of the profit and loss account, including the amount brought forward, was £232,429, an increase of £47,000 over the previous year. It was proposed to pay a dividend of 21½%, which would absorb £60,000, and place £16,250 to reserve fund, adding the sum of £40,000 to the reserve suspense, which leaves £49,525 to be carried forward. A new smelting plant of the most up-to-date character has just been completed at Coniston, Ontario, and is now working continuously. It is also expected that during the current year the extension of their works in South Wales will be completed.

At an extraordinary general meeting of Joseph Watson & Sons, Ltd., the Chairman moved the resolution that the capital be increased to £1,400,000 by the creation of 260,000 new ordinary shares of £1 each.

The report of the Cicely Rubber Estates Company for the year ended March 31st, shows a net profit of £32,732. The directors propose to pay a final dividend of 77½% on the preference shares (making a total of 155% for the year) and 75% on the ordinary shares (making 150% for the year), and carry forward £6,019, leaving £7,000 to be placed to reserve. The output of dry rubber amounted to 249,239 lbs., and it is estimated that upwards of 280,000 lbs., of dry rubber will be harvested during the current year.

The Union Cold Storage Co., Ltd., show earnings for the past year of £133,000, an increase of £22,000 over the previous year's working. The directors propose the usual dividend of 10% on the ordinary shares, and 6% on the preference shares, leaving £20,800 to be carried forward against £18,604 last year.

The United Alkali Company, at a recent meeting of shareholders, resolved to reduce its ordinary share capital from £3,000,000 to £600,000 by cancelling paid-up capital to the extent of £8 a share, making the nominal value of the 298,343 shares £2 each.

⁸ The author has pointed out the parallelism between viscosity and swelling eight years ago. (*Pflüger's Arch.*, 108, 563 (1905), 109, 277 (1905), 111, 581 (1906).)

⁹ This temperature of gelatinisation agrees entirely with that found by optical methods by M. Samec (*Koll. Beihefte*, 3, 129 (1911)).

¹⁰ Wo. Ostwald, *Grundr. d. Kolloidchemie*, 1st ed., 1909, p. 267.

¹¹ H. W. Woudstra, *Koll.-Zeitschr.*, 8, 73 (1911), where references to earlier work are given.

REVIEWS OF BOOKS.

"MODERN LAUNDRY WORK." By Ellis Clayton. SIMPKIN, MARSHALL, HAMILTON, KENT & Co., LTD., London, 1912. Pages 366 + viii, including Appendix and Index. Divided into 2 Parts with VIII. Chapters, and 139 Illustrations. Price 12/6 net.

THIS new work on laundry practice has certain merits which are at once obvious to the reader. It is divided into two sections dealing respectively with the technology of textile fibres, water and machinery used, and actual practice. Short chapters dealing with the common fibres such as silk, cotton, wool, linen, jute, etc., are well arranged and the photo-micrographs illustrating the same are clear, and to the point. The chapter dealing with materials used in laundry work is also satisfactory, the particulars concerning malt extract and its uses being of special value at the present juncture. The section dealing with stiffening materials is also satisfactory. The one on water and its uses is short, and the description of water softening apparatus is confined to two well-known types, with a reference to the Permutit process. The chapter on machinery is clearly written and well illustrated, and in its 98 pages a good account of typical types used under modern conditions is given. This work is probably the most complete one which has appeared in this country on this important subject.

"SOIL CONDITIONS AND PLANT GROWTH." By Edward J. Russell. LONGMANS, GREEN & Co., London, 1912. Pages 168 + vi, including Appendix, Bibliography, and Index. Chapters VII., including Diagrams. Price 5/- net.

It goes without saying that this volume gives a satisfactory account of the important subject dealt with. The study of the soil as a medium of plant life is an absorbing one, and recent results are of increasing value to the practical man. Respective chapters deal with the requirements of plants; constitution of the soil; biological conditions of the soil; soil in relation to plant life; and soil analysis. A short introductory chapter deals with the historical side of the subject. The work concludes with a selected bibliography which will be found of great use for reference purposes. The writer is to be congratulated upon the lucid way in which the subject is treated. This volume will form a satisfactory book of reference for all those interested in this fascinating subject.

"SULPHURIC ACID AND ALKALI." By George Lunge. Fourth Edition. Vol. I., Parts I., II., III. GURNEY & JACKSON, London, 1913. Pages 1617 + xii, including Addenda, and Indexes. Chapters XIV., with 543 illustrations. Price 63/- net.

A perusal of the fourth edition of this monumental work indicates in the clearest manner its extreme value to the technical chemist. It is impossible, within the scope of this review, to do justice to the

book which has long been recognised as the standard work on the subject. The first volume deals with the raw materials used, including nitric acid; analysis of the oxides and acids of sulphur; production of sulphur dioxide; construction of lead chambers; recovery of nitrogen compounds; the chamber process itself; and the purification of sulphuric acid and its concentration. The final section deals with the manufacture of Nordhausen acid and sulphuric anhydride.

The second volume deals with the construction of lead chambers; recovery of nitrogen compounds; chamber process; and purification of the acid formed.

The third volume also deals with concentration, arrangement of sulphuric acid works, yields and costs, and the manufacture of Nordhausen acid and sulphur anhydride. A chapter deals with other processes for manufacturing sulphuric acid, and another with by-products of the manufacture. Interesting data concerning the application of the acid and statistics are also given.

Volumes I. and III. contain addenda dealing with important details. The work is crowded with useful data and the illustrations and plans are a feature of this remarkable work which, beyond all doubt, will remain the standard book of reference on both the chamber and contact processes. In its revised state the new edition amounts to practically a new work.

"TRAITÉ COMPLET D'ANALYSE CHIMIQUE APPLIQUÉE AUX ESSAIS INDUSTRIELS." By J. Post and B. Neumann. Translated into French by G. CHENU and M. PELLET. Second Edition. Pages 468. Chapters XXXVIII. with 56 Figures. A. HERMANN ET FILS, Paris, 1912. Price 15 francs.

This is the first part of the third volume of the French edition, for which such well-known authorities as P. Wagner, Ch. Nussbaum, J. Helle, R. Kissling, H. Kast, and others equally important have contributed sections.

The first section deals with fertilisers, including interesting particulars concerning ammonium superphosphates, mixed manures, etc. A second and shorter section deals with the analysis of arable soils and agricultural products.

The one on essential oils is particularly complete, and contains information of great value to the commercial analyst. Dr. Max Philip is responsible for the section devoted to leather and tannin materials, which also gives important data concerning the analysis of these materials.

The article on glue is also in its way of value. Others deal with tobacco, caoutchouc and gutta-percha, and a particularly complete one dealing with natural explosives and matches completes this interesting work.

This second French edition is prepared from the third German one, but it has been augmented by many valuable additions. It can be thoroughly recommended to all those interested in commercial analysis, more, particularly from the continental standpoint, and will be of special service to those who may prefer to refer to this work in French rather than the original German.

"TANNERS' YEAR BOOK, 1913." Edited by M. C. Lamb and J. Gordon Parker. THE TECHNICA PUBLISHING CO., London. Pages 178, with numerous Illustrations and Tables. Price 3/-.

This volume, which is edited by M. C. Lamb and J. Gordon Parker, contains twenty-seven papers by recognised authors, on interesting subjects connected with the tanning industry. It also includes particulars of the Trade Tanners' Federations with a number of photographs of the leading officials, and a report of the work of the Central Committee of the United Tanners' Federation, which deals with technical scholarships, adulteration of leather, and other interesting points.

Among the more interesting of the articles are those written by the editors, Professor H. R. Procter, J. R. Blockey, J. T. Jackson, and Professor Stiasny. This volume should prove one of exceptional interest to those connected with this important industry.

BOOKS, ETC., RECEIVED.

"Chemistry of Rubber," by E. D. Porritt. Gurney & Jackson, London, 1913. Pages 96 + vi, with Bibliography and Index. Sections VI. Price 1/6 net.

"The Textile Fibres," by J. Merritt Matthews. Third Edition, Rewritten. Chapman & Hall, Ltd., London, 1913. Pages 630 + iv, with Index. Chapters XIX., including 141 Illustrations. Price 17/- net.

"Biochemical Bulletin," April, 1913. Vol. II. Pages 153, with 6 Plates. Columbia University Biochemical Association, New York, U.S.A.

"Collected Papers from the Research Laboratory of Parke, Davis & Co.," Detroit, Michigan, U.S.A. Vol. I., 1913. Pages 287 with numerous Illustrations.

"The Fundamental Properties of the Elements," (Faraday Lecture), by Theodore William Richards. Smithsonian Institution, Washington, U.S.A., 1912. Pages 17.

"Accidents from Falls of Roof and Coal," by George S. Rice. Miners' Circular 9, Bureau of Mines, Washington, U.S.A., 1912. Pages 15.

"Training with Mine-Rescue Breathing Apparatus," by James W. Paul. Technical Paper 29, Bureau of Mines, Washington, U.S.A., 1912. Pages 16.

"Sampling Coal Deliveries and Types of Government Specifications for the Purchase of Coal," by George S. Pope. Bulletin 63, Bureau of Mines, Washington, U.S.A., 1913. Pages 68, with 4 Plates and 3 Figures.

"Oil and Gas Wells through Workable Coal Beds," by George S. Rice, O. P. Hood and others. Bulletin 65, Bureau of Mines, Washington, U.S.A., 1913. Pages 101, with 1 Plate, and 11 Figures.

"Mine Fires and How to Fight Them," by James W. Paul. Miners' Circular 10, Bureau of Mines, Washington, U.S.A., 1912. Pages 14.

COMMERCIAL AND GENERAL NOTES.

Decreasing Graphite Production in the United States.

According to a monograph which the United States Geological Survey has published on the production of graphite in the country in 1912, a considerable decrease in the production has taken place. During the year covered by the report only 2,445 short tons of natural graphite, valued at £207,033, have been produced, representing the smallest quantity mined during the last six years. In an introduction to this monograph the author says: A considerable quantity of material is produced in Bartlow county, Ga., which cannot be properly classed as graphite, but is rather a slate carrying from 2 to 15% of carbon, probably in part graphite. It is ground for use as a filler and drier in fertilisers. In 1909 the production of this material was included in the statistics under the heading "Amorphous Graphite," but it is not adapted for any of the purposes for which higher grades of amorphous graphite are used, and as these higher grades are never used as fertiliser filler, it is deemed best not to include this material under the name graphite.

The bulk of the graphite consumed in the United States continues to be derived from foreign deposits. In 1912 the quantity of graphite imported was 25,643 short tons, valued at £1,709,337. In contrast to this the total domestic production was 2,445 short tons of natural graphite, valued at £207,033, and 6,448 short tons of manufactured graphite, valued at £830,193. It occurs as, and is known by the names of graphite, plumbago and black lead; the term graphite usually referring to the American product, plumbago to the Ceylon product, and black lead to the inferior grades of graphite.

Rust on Iron Caused by Paints.

In some interesting experiments carried on by two German chemists, E. Liebreich and F. Spitzer, the cause of rust in cases which have seemed especially puzzling has been made clear—as it was shown beyond question that the rust was caused by the paint itself. Polished steel plates were painted, and in order to distinguish them, numbered with oil paint. The result was that the rusting took place just under the painted numbers—that is where the "protective" coating was the thickest.

They went further in the matter, and examined iron business signs and the like. As a rule these were made of sheet iron, first painted with a ground colour, mostly white, then the lettering was added usually in black. Removing the coating, it was shown that the rust was most pronounced under the lettering; in fact in most cases was to be found only there. This gave the investigators a clue, and they carried out experiments with several kinds of paints, such as white lead, zinc white, red lead, zinc white and lampblack, etc. The result was interesting. Under all the single coatings the iron was not at all rusty; under the double coat, partly attacked, and under the triple coat, more strongly. Under the four coats it was thoroughly rusted. Apparently one coat is better than more. The explanation of this remarkable result would seem to be that the varnish in the second coat dissolves and

loosens the first one, making it porous, and that the oftener this process is repeated, the more porous the paint becomes. It would also seem to indicate that one thick coat, if allowed to harden, would be better than several thin ones, which has not been considered to be the case.

German Tar Products.

The sales of the Union of German Tar Producers during last year amounted to 947,107 tons, showing an increase of 150,543 tons over those of 1911. This increase was mostly due to the lively demand for tar oil and pitch. The more favourable result of the pitch trade is not only the consequence of an increased consumption for the purpose of briquetting coal smalls, but is also caused by developments in other directions, *e.g.*, its use for the briquetting of ore. Tar oil was mostly used as fuel for Diesel motors and as heating fuel in the heavy metal industries.

Benzol and its derivatives have also been sold in large quantities, but the production of naphthaline and anthracene has been slightly reduced. The makers of piridine products have been able to sell their production at very satisfactory prices.

Denatured Alcohol as Carbon Deposit Remover.

The subject of cleaning motor cylinders from carbon deposits by the use of denatured alcohol has been attracting much attention, especially since some of the lower grades of gasoline have come into use as a fuel. At a recent meeting of American Automobile Engineers, some interesting experiments were discussed which the president of the Metropolitan Section has carried out. These experiments have shown that denatured alcohol introduced in the combustion space of an automobile cylinder which is at the working temperature of the engine will loosen the carbon deposit so as to permit the deposit to become separated from the walls of the combustion space and pass out of the cylinder with the exhaust gases when the engine is run. Due to the cleansing action of denatured alcohol, an engine which has been in service for an extensive period will show a marked increase in operating efficiency.

Denatured Alcohol Conditions in Europe.

Announcement is made by the officials of the Bureau of Foreign and Domestic Commerce that arrangements have been made for a report by a special agent of the department upon the use of tax-free alcohol for industrial purposes, namely, denatured alcohol, in a number of countries in Europe.

The bureau published in December last a report on this subject made up from letters received from consuls in various countries, but it is considered desirable at this time to have a special report by an agent familiar with the manufacture and applications of industrial alcohol that will cover the field of the countries which make the most extensive use of the privilege of tax-free alcohol. The report will be based upon a personal investigation by the agent of the bureau, of the sources, manufacture, governmental inspection and encouragement, and all matters of interest in connection with denatured alcohol from the standpoint of its production, together with its various applications in different lines of industry, the cost to consumers, its relative merits as a liquid fuel for internal combustion engines, etc. The investigations will be made during the summer and the report published in the autumn.

Three New Metal Alloys.

In their last official report, the chemists to the American Institute of Metals mention three new alloys among the various items of recent progress in the metal industry. A French patent has recently been issued covering the product of two types of alloys from copper, zinc and silicon, which are claimed to possess great tenacity, resistance to acids and alkalies, and to be capable of rolling into finished shapes. Another new alloy has been patented. This is composed of iron, nickel and copper, which is claimed to be non-corrosive, malleable, of great tensile strength and capable of being rolled, drawn or cast. A new type of pyrophoric alloy has been patented in Germany which consists of the addition of 5% metallic cerium to an alloy of manganese and antimony. The inventor claims excellent pyrophoric properties from this alloy, which is essentially different from the other alloys of this type in which cerium is the main source of the pyrophoric characteristics.

The Prospects for Whaling Stations in Australia.

According to Mr. Stead, an Australian Government fisheries expert, whaling on the Australian coast has a chance to develop into a profitable industry. The first steps would necessitate the establishment of some shore stations, equipped with all modern appliances for treating the blubber, *e.g.*, extracting the oil and preparing the different by-products for use. The shore stations have this advantage over the so-called floating oil factories that there need not be any waste whatever. Quite a number of different by-products could be obtained, such as whale grease, serving as a basis for fertilisers, as it contains from about 10—12% of ammonia and 50% of phosphates. Provided the work is thoroughly organised, there is an opportunity of making it very profitable in the Southern Seas.

In connection with the foregoing paragraph it may be mentioned that a new whaling station is in the course of construction on the Bluff at Durban. The oil will be extracted chemically by means of benzine after a German process. This process has already been used for the treatment of fish offal and is said to yield a higher percentage of oil than all other methods.

M. L.

INSTITUTE OF CHEMISTRY.

Pass List: June—July Examinations, 1913.—Of 33 Candidates who presented themselves for the Intermediate Examination, 16 passed: R. L. Amore, R. O. Bishop, A. Dingwall, J. W. Donaldson, B.Sc. (Edin.), J. G. Duncan, A. Dunsmore, J. S. Frith, Peter Kerr, B.Sc. (Edin.), K. G. Lochhead, J. W. Lorimer, H. V. Parker, B.A. (Cantab.), H. C. Reynard, F. Smith, F. W. Snelgrove, B.Sc. (Lond.), A. R. Steele, and A. F. Weiss, B.Sc. (Lond.). Of 45 Candidates who presented themselves for the Final Examination, 24 passed. In the Branch of Mineral Chemistry: B. Campbell, B.Sc. (Lond.), J. A. Pickard, B.Sc. (Lond.), A.R.C.S. (Lond.), E. A. Rayner, B.Sc. (Lond.), and E. W. Skelton, B.Sc. (Lond.); in the Branch of Metallurgical Chemistry: R. J. Dunn, B.Sc. (Birm.); in the Branch of Physical Chemistry: (Miss) G. Thompson, B.Sc. (Lond.); in the Branch of Organic Chemistry: J. S. Bainbridge, B.Sc. (Leeds), A. L. R. Clarke, B.Sc. (Lond.), A. Cunningham, B. B. Dey, M.Sc. (Calcutta), J. R. Gray, G. N. Grinling, E. S. Hawkins, B.Sc. (Birm.), P. C. R. Kingscott, A.R.C.S. (Lond.), D. E. Sharp, B.Sc. (Aberdeen), T. F. Smeaton, E. W. Smith, B.Sc. (Lond.), and R. Wheatley, B.Sc. (Leeds); in the Branch of the Chemistry of Food and Drugs, and of Water: (Miss) D. J. Bartlett, H. B. Brown, D. W. Kent-Jones, B.Sc. (Lond.), H. A. Phillips, H. V. Potter, and S. H. Stroud.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.

4702/12. T. BOBERG AND TECHNO-CHEMICAL LABORATORIES, LTD. **Catalytic Agents.**

A method of preparing a catalyst for the hydrogenation of organic substances consists in reducing by hydrogen a metallic compound, such as ignited nickel carbonate, under such conditions that in the resulting catalyst the metal exists wholly or mainly as one or more suboxides.

5677/12. E. WRIGHT. **Machines for Decorticating Fibrous Material.**

5975/12. E. W. COX and H. M. MORRIS. **Concentrating Apparatus for Separating Metals, Ores, and other Substances in Wet Recovery Processes.**

10062/12. D. D. ROBERTSON and M. WOLLENWEBER. **Explosive.**

To render an explosive to some extent flameless or smokeless, a solution of a metallic tartrate or oxalate is employed to coat the waterproofed explosive, strip, cord, or the like, or the granule or flake cut off a strip or cord.

12308/12. I. P. LLEWELLYN and PETER SPENCE & SONS, LTD. **Calcination of Aluminous Materials.**

12562/12. J. D. OLIGNY. **Process for Obtaining Gas from Peat, Oil, Sawdust or like Material.**

12563/12. J. D. OLIGNY. **Process for Obtaining Gas from Peat, Oil, Sawdust or like Material.**

12749/12. H. KRETZER. **Enamels and Ceramics.**

A method of manufacturing dulled glass, enamels, glazings, ceramic colours and the like is characterised by the employment, as dulling or opacifying agent, of the oxygen combinations of antimony with alkaline earth metals, such as barium, strontium, calcium or magnesium, or with aluminium, and often with magnesium or aluminium.

12770/12. F. E. MATTHEWS, E. H. STRANGE and H. J. WHEELER. **Explosives.**

The invention consists in the manufacture and production of explosives by nitrating glycols having the OH groups on neighbouring carbon atoms or oxides corresponding thereto.

12771/12. F. E. MATTHEWS, E. H. STRANGE and H. J. W. BLISS. **Manufacture of Butadiene and its Homologues.**

12773/12. F. E. MATTHEWS, E. H. STRANGE and H. J. W. BLISS. **Manufacture or Preparation of Caoutchouc or Caoutchouc-like Substances.**

13050/12. CHEMISCHE FABRIK GRIESHEIM-ELEKTRON. **Blast Furnaces.**

Air for supply to blast or other like furnaces is dried by means of a solution of caustic soda, or potash. The air is also deprived of its contained carbon dioxide before entering the drying apparatus.

13577/12. A. HELFENSTEIN. **Refining Metals.**

A process of refining metals, particularly iron, by means of electric and fuel heating is characterised by the fact that the heating of the metal bath is effected in an extended, tubular furnace chamber by means of fuel heat conducted over the metal and short circuit current transmitted longitudinally through the metal.

13659/12. A. HAUSSMANN. **Sewage Treating Installations.**

According to this invention, a concentric arrangement for sewage purification comprises a sand-depositing and fat-skimming chamber, a collecting chamber and putrefying chamber, an oxidising chamber and a central control pit and collecting well, the flow being first in a circular direction through annular chambers at the periphery of the concentric structure, and then radial towards and in to the central well.

14079/12. F. PERRY. **Ammonium Salts.**

Ammonium salts are manufactured from the ammonia occurring in Mond, or other producer, coke oven, illuminating and like gases simultaneously with the removal of sulphuretted hydrogen from such gases by subjecting the gases to the single operation of washing or treating with a solution of sulphate or chloride of iron, or waste pickle, without subsequent purification of the resultant liquor by oxidation.

14138/12. I. T. HAWKINS. **Process and Apparatus for the Extraction of Vegetable Oils.**

14223/12. W. R. BOUSFIELD. **Apparatus for the Distillation of Liquids.**

14555/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & Co. **Manufacture and Production of New Azodyes.**

14742/12. LEOPOLD CASSELLA & Co., G.m.b.H. **Halogenated Rosanilines.**

The manufacture of halogenated rosanilines is effected by heating an ortho halogen substituted aniline, or a homologue thereof with para-aminobenzaldehyde, or a homologue or halogen substitution product thereof and arsenic acid.

15459/12. G. K. DAVIS. **Manufacture of Sulphuric Acid and Apparatus therefor.**

16385/12. H. P. HIRD, E. V. CHAMBERS and T. C. HAMMOND. **Method of and Apparatus for Washing Coal Tar, Mineral or other Oils.**

19702/12. F. LAMPLUGH. **Oil Distillation.**

A process for converting heavy hydrocarbon oil into lighter oil consists in bringing the heavier oil together with water or steam into contact with nickel in a retort maintained at a dull red heat, or thereabout.

20108/12. E. BRACQ. **Roasting Ores.**

A process for roasting ores and the like consists in continuously dividing a layer of material on a furnace hearth into separate divisions of small width and feeding forward said divisions of the layer one by one.

21199/12. W. W. STRONG. **Device for Detecting Suspended Matter in Gases.**

21223/12. P. BERGSÖE. **Metal Recovery Process.**

A process for purifying or recovering tin from alloys or mixtures containing foreign metals which are present in such small quantities that they are within the eutectic limit, consists in a systematic fractional crystallisation of the tin, the crystals when formed being removed from the solidifying alloy and consisting of pure tin, while the impurities remain in the mother liquor.

22092/12. C. and G. MÜLLER SPEISEFETTFABRIK, AKTIEN-GESELLSCHAFT. **Metallic Catalysts.**

In the process for the production of metallic catalysts, according to this invention, compounds of the metals in question are reduced and glowed in hydrogen, and the product thus produced is then glowed in a stream of carbonic acid.

22557/12. J. M. NEIL. **Potash Recovery Process.**

23643/12. C. and G. MÜLLER SPEISEFETTFABRIK, AKTIEN-GESELLSCHAFT. **Production of Metallic Catalysts.**

24636/12. M. F. PURCELL, J. H. RYAN and C. J. POLYGLASE. **Sewage Sludge Treatment.**

For destructively treating sewage sludge in a producer, steam and air are supplied to the underside of the grate of the producer, the air being at a higher temperature than the steam.

24637/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & Co. **Process of Producing a Substance similar to Caoutchouc.**

25680/12. C. F. KÜBLER. **Treating Vegetable Fibres.**

A method of opening out fibrous plants, especially those containing bast fibres, is characterised by the fact that the raw materials comprising the fibres are submitted to a steeping operation and to freezing and heating.

27227/12. CHEMISCHE FABRIK AUF ACTIEN (VORMALS E. SCHERING) and A. LOOSE. **Treatment of Acetyl Cellulose.**

29030/12. M. RUTHENBURG. **Sulphur.**

In the process for the reduction of sulphur dioxide, in which the gas is passed through a heated column of carbonaceous material, the products then being passed through a condensing chamber and finally washed, the column of carbonaceous material is, according to this invention, heated electrically, so that the process may be maintained continuously.

834/13. H. KOPPERS. **Process of Producing Sulphate of Ammonia from Ammoniacal Gases or Vapours.**

3474/13. L. LADEWIG. **Production of a Lasting Sodium Flame with Oil Lamps or Gas Burners.**

3575/13. ELEKTRIZITÄTWERK LONZA AKTIENGESELLSCHAFT. **Electrolytic Apparatus.**

Apparatus for the production of alkali metal from fused alkali haloids by electrolysis comprises a furnace chamber, in which a partition wall of insulating material, structurally independent of the rest of the furnace, and especially from the collecting cathode, is pressed against the cathode, so that, in consequence of the deflection of the flow of current which keeps the electrolyte fluid, a layer (which may be strengthened by cooling) of solidified salt is formed, which cements the partition walls to the electrode, and which, by increasing the current, can be softened to such an extent that the partition wall can be easily changed without stopping the work and without interfering with the rest of the furnace apparatus.

3948/13. O. HAPPEL. **Apparatus for Filtering Gaseous Fluids.**

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Ditto. 4% Pref. (S)	95	98	94	96
Greenwich Lino. (1/2)	3 ¹ / ₂	3 ¹ / ₂	3 ¹ / ₂	3 ¹ / ₂
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India Rubber Co. (10)	11 1/2	12 1/2	11	12
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Neuchâtel Asphalt. (10/-)	9	9 1/2	9	9 1/2
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Ditto. Bearer (10)	16 1/2	17 1/2	16 1/2	17 1/2
Ditto. 5% Pref. (10)	10 1/2	11 1/2	10 1/2	11 1/2
Pears, A. and F. Ord.	1 1/2	1 1/2	1 1/2	1 1/2
Ditto. 6% Pref. (10)	11 1/2	12 1/2	11 1/2	12 1/2
Price's Candle. (16)	35	37	35	37
Rosario. (5)	9 1/2	9 1/2	8 1/2	9 1/2
Salt Union. (4)	3	1/2	3	1/2
South Metropolitan 4% Standard (S)	109 1/2	111 1/2	108	110
Ditto. 3% Debenture (S)	71 1/2	73 1/2	73	75
United Alkali. (10)	1 1/2	1 1/2	1 1/2	1 1/2
Ditto. Pref. (10)	9 1/2	10	9 1/2	9 1/2
Val de Travers	1 1/2	1 1/2	1 1/2	1 1/2

TRADE ITEMS.

Messrs. James Keith, Blackman & Co., Ltd., have issued a small pamphlet dealing with the important subject of factory and other lighting. Illustrations show the effect of good lighting under conditions mentioned, and there is no doubt but increasing attention is being given to this subject.

An illustrated pamphlet by Crossley Bros., Ltd., contains a description of their exhibit at the Agricultural Society's Show, Bristol, showing the advantages of their well-known types of gas and oil engines, and suction gas plants.

Catalogues to hand from the Uskside Engineering Co., Ltd., Newport, Mon., describe in some detail their mining plant, including steam and electric winding and hoisting engines, hauling engines, mine pumps, and also briquetting machinery, constructed on the Stevens system.



THE CHEMICAL WORLD

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"Science moves, but slowly, slowly creeping on from point to point."—TENNYSON.

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The Medical Congress.

THE attention of the public has been drawn to the advance of science by this latest Congress in a satisfactory manner. Medicine now works in as open a way as any other science, and the results obtained under modern conditions of research are as astonishing in their variety as their value.

The address by Professor Ehrlich was happy in its reference to the part English investigators have played in the past in the fight against infectious diseases. His claim that the use of such powerful agents as arsenic and mercury should be judged by their direct action rather than by the phenomena of super-sensibility of individual patients is sound logic. He definitely claimed that the new method of chemo-therapeutics, if not always easy, suggested a practical way of combating certain specific diseases. When dealing with the diseases like small-pox or typhus (which were claimed to be due to super-parasites) he anticipated that the next five years would produce results of the highest importance.

Dr. Bashford's address on cancer research in this country was of great interest. The suggestion made by Dr. L. Barlow that, as judged by certain tests, radium was actually present in cancer tissue, and even in the non-cancerous tissue of the affected subject, is striking. It was even claimed that this element might be present in the ratio of 23 to 1 as compared with a non-cancerous subject. Also that the proportion of potassium was higher in a cancerous subject—a further advance in the direction of chemical pathology.

Dr. Charlton Bastian, of University College Hospital, again brought forward his experiments on spontaneous generation of life. Starting with "sterilised" sealed tubes containing certain chemical substances he claimed to be able to watch the subsequent growth of forms of matter which have the closest resemblance to elementary forms of vegetable life. Dr. Bastian now claims to have proved that these forms have the power of reproduction and actual growth. At any rate this investigator has the courage of his conviction, for his experiments in

the past have met with the greatest opposition from certain of his co-workers.

It may be that the forms observed are similar in their origin to those obtained by Professor Leduc as illustrated in his recent work, "Le Biologie Synthétique," where the outward form of certain colloidal aggregations is astonishingly like that of certain forms of vegetable life. If Dr. Bastian's experiments are considered in the light of these results, further progress may possibly be recorded in the direction of their elucidation.

The use of veronal was upheld by Professor Cushny as reliable on a test of a scale of millions of cases, and ranked with chloral.

Sir William Collins pointed to the need of progress in medico-legal instruction, and contended that it would benefit by university recognition. Such progress in surgery was reported that the mortality primarily due to this was "fast reaching the vanishing point."

In view of the demand for a Royal Commission on contagious diseases, it may be noted that the Cantonment Act in India has led to a reduction of hospital cases of venereal diseases from 537 admissions per 1,000 in 1895 (!) to 59 in 1910. Education and treatment were more generally advocated than compulsory notification.

It is interesting to note to what an extent this science has progressed, and the tendency for the medical profession to turn to chemo-therapeutics as one of the chief aids to future progress.

Agriculture and Research.

Recent developments at the agricultural stations in this country, as recently outlined by the President of the Board of Agriculture, cannot fail to have a definite influence on the future of agriculture in this country. It would seem that at last this subject is being tackled in the right spirit, and that the Government, through the Development Commission or otherwise, is giving substantial and increasing financial support to the many institutions which are now conducting agricultural research. The Imperial College is dealing especially with plant

physiology, and the important station at Cambridge with plant breeding and animal nutrition.

One could not fail to be struck, at the recent opening of the extensions at the Rothamsted Station, with the fact that the modern treatment of the subject of agricultural chemistry is slowly but irresistibly modifying the relationship between science and agriculture.

It is interesting to note that the rapid changes which have taken place have compelled the organisers to train a number of chemists in agricultural chemistry, and with this object in view thirty-six scholarships of £150 per year, tenable for three years, have been awarded. The appointment of advisers in connection with the agricultural stations, whose sole function is to transmit direct to the farmers results of research work, is an additional and important link in the new scheme. The Board of Agriculture has actually granted £9,000 a year towards the salaries of these advisers, and £20,000 for agricultural research. This great advance is a matter for congratulation, and is a definite reward for the labours of that small body of scientific men who for many years past attempted to direct the attention of agriculture to the work of chemists. Among these the name of Professor H. E. Armstrong may be mentioned, for his untiring devotion to the work conducted at Rothamsted has perhaps more than anything else played a part in shaping the policy which has led to the recent developments at that station.

An important article dealing with certain methods of analysis as standardised in the new organic laboratory at Rothamsted appears in this number.

Academic & Industrial Appointments.

Some six months ago the University of London appointed Dr. A. D. Denning to be full-time secretary to its Appointments Board. From a notice in a recent issue of the *London University Gazette* it appears that within the past three months about 1,000 posts were notified to suitably qualified graduates registered with the Board and many appointments secured. The Appointments Board, constituted by the Senate to assist graduates and students of the university in obtaining appointments, and to co-ordinate and supplement the work done by the schools and institutions of the university in this direction, registers the qualifications of graduates of the University of London, graduates of other universities who are students of London University, and London undergraduates in their last term previous to entry on degree examinations. A short time ago, in a conversation with the secretary, we gathered that almost all the First Class Honours chemistry graduates are absorbed into the service of educational authorities—largely because of the better initial salary conditions obtainable therein as compared with those obtainable by young graduates starting in the industrial chemical world. This is distinctly unfortunate, and we cannot too strongly urge upon the English chemical manufacturers the importance of their securing the best products of our universities. The additional

remuneration which would have to be offered is a negligible factor for a large concern. To speak quite plainly, it is open to question whether certain manufacturers are altogether keeping their end up in this respect. As we have before pointed out, the modern manufacturer owes it to his workmen that he shall insure them against undue competition, and that they shall work under the best conditions. The presence of a first-class chemist in a works is in many cases a way of complying with such conditions.

Future of Industrial Alcohol.

It will be remembered that in a recent number of this journal (*CHEMICAL WORLD*, 1913, 11, III) Professor Vivian B. Lewes laid stress upon the future of alcohol as a substitute for petroleum products, when used as a motor spirit. This matter has again been brought forward in a joint paper recently read before the Imperial Motor Transport Conference by Sir Boverton Redwood and Professor Vivian B. Lewes. If the general conclusions arrived at, especially when taken in conjunction with the data given in a paper by W. J. A. Butterfield, as read at the same Conference, are considered, it would seem that greater steps will have to be taken to investigate the problem in some detail. Mr. Butterfield estimates that 100,000,000 gallons of motor spirit are now being consumed in the United Kingdom annually, and that this quantity will automatically increase for some time to come. By the side of such a figure the benzol recovered from coal tar is a trifling matter, and it must be remembered that a large proportion of this is already required in certain chemical industries. It is possible that when the old beehive coke ovens have been entirely replaced by more modern plant, that an additional 30,000,000 gallons of motor spirit per annum will be obtained. Also that the "stripping" of coal gas might yield a further 30,000,000 gallons of motor spirit, but there would be a corresponding reduction in the value of the treated gas as tested by standard methods in vogue to-day. The oil shales at present quarried in the United Kingdom might also give, by suitable "cracking," a total of 30,000,000 gallons of motor spirit, but there again this would be partly required in other directions.

The suggestion that within a reasonable period alcohol will replace petrol, or even become the general fuel of the future, may at first sight be regarded as Utopian. That the human race would benefit by the substitution of alcohol for that of petrol with its involved claim on certain mining operations is obvious.

It will be remembered that some years ago the German Emperor strongly urged his countrymen to consider the advantages of the use of alcohol for motor purposes, more especially in its influence on economic conditions; but it is evident that no general movement has materialised in this direction.

If alcohol can be produced at anything under one shilling a gallon, it will compete with petrol and stand a good chance of being recognised as the ideal spirit in the future. The change involved in methods of manufacture would certainly be beneficial to this country.

CHEMICAL ADAPTATION TO ENVIRONMENT.

By E. FRANKLAND ARMSTRONG, D.Sc., Ph.D., F.C.G.I.

ADAPTATION to environment is a well-established phenomenon of biology although the subject is still a matter of controversy. There can be no doubt that the changes which are manifest outwardly are the result of internal chemical changes, but the nature of these latter is in most cases a mystery. Knowledge on the chemical side of the question is very scanty, and a good deal of experimental work must be done before any definite ideas can be formulated. The biological chemist is only beginning to investigate the subtle differences which exist in the composition of the organs or tissues of closely related animals. In the plant world the problem is perhaps a little more simple, but no systematic analysis of the chemical constituents of a group of plants has yet been attempted which would enable their classification on a chemical instead of on a morphological basis. However, a beginning has been made in more than one direction, and the results cannot fail to afford an important addition to knowledge.

In the following, certain experiments with enzymes are described, which throw some light on the vexed questions of adaptation. A controversy ranges round the possibility of an organism acquiring, as the result of environment, a new enzyme which it did not possess previously. The experimental study has been confined mainly to yeast and mould fungi or to bacteria, all of which are well-known to act selectively on the carbohydrates and on the proteins. Though it is believed that the biochemical properties of many organisms undergo marked variation as the result of environment, it is denied that any organism can be caused to acquire an altogether new and distinct property in this manner.

Hansen and his school, to whom we owe so much of our knowledge of yeasts, have never found evidence of the formation of new enzymes as the result of the culture of the organism for several generations in presence of a material which it was unable to attack initially. On the other hand, Pottevin, of the Pasteur Institute, claims to have been more successful. The mould fungus *Aspergillus niger*, cultivated in presence of cane sugar, contains in its mycelium a number of enzymes, but none of these are able normally to hydrolyse either α - or β -methylgalactoside. Pottevin cultivated the fungus for a few generations in presence of either of these galactosides together with other carbohydrate nutrient, and again tested its behaviour towards the methyl galactosides. The mycelium grown in presence of the α -isomeride was now able to hydrolyse it, whilst that grown in presence of the β -galactoside effected the decomposition of this isomeride only. Pottevin advances this experiment as proof that new enzymes have been acquired by the mould.

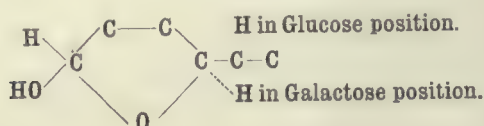
However, his results have not been at all generally accepted, and they are directly contradicted by recent experiments of Dox and Neidig (*Biochem. Zeits.*, 1912, 46, 397). The same mould, *Aspergillus niger*, when cultivated in cane sugar solution has only very little, if any, action on α -methylglucoside. It did not acquire any increased power to hydrolyse this glucoside as a result of prolonged cultivation in its presence.

In the case of those enzymes of yeast, which cause alcoholic fermentation, adaptation to environment has apparently been observed, although it is improbable, as will be shown, that this really represents the formation of an entirely new enzyme. In addition to the countless varieties of industrial brewers' yeast which are all classified, however, as *Saccharomyces cerevisiae*, there are several other species known to mycologists—the so-called wild yeasts. The wild yeasts not only exhibit characteristic morphological variations, but differ also in the sugar-splitting enzymes which they contain. They differ also in their power of fermenting the simple sugars. Some of them, for example, are unable to ferment galactose, a sugar which, although closely related to ordinary glucose, differs from it slightly in chemical constitution.

Brewing yeasts, though classified as one species, exhibit, as every brewer knows, very marked variations with regard to the type of fermentation they produce. So far as is known, they all contain the same sugar-splitting enzymes, and they all ferment glucose. Some of them, however, are unable to ferment galactose when first brought in contact with this sugar. Harden, and subsequently Euler, have proved beyond question that if such yeasts are grown for a few generations in presence of galactose, as a result of the environment, they acquire the power to ferment this sugar. In the case of the wild yeasts Armstrong, Euler, and others were unable to bring about similar accommodation. Many of these yeasts normally ferment galactose, but those which did not attack this sugar could not be trained to do so.

However, the apparent contradiction is not difficult to explain. The typical *S. cerevisiae* normally contains a zymase able to attack galactose; indeed, the descendants of the original pure culture of Scotch brewers' yeast made by Hansen still ferment galactose. In some commercial varieties of this yeast, which have been propagated for countless generations in beer wort in the absence of galactose this galactozymase has been lost temporarily or its activity has become dormant. In consequence, the yeast is now unable immediately to ferment the strange sugar, but as Harden's experiments witness, this power is readily acquired again on cultivation.

There must be a fundamental difference between the recovery of an enzyme present in the type, but temporarily in abeyance in the variety and the formation of an enzyme, altogether foreign to the type, as the result of environment. As yet we have no experimental evidence in support of the second possibility. These experiments possess an interest beyond their chemical significance, since they bear on the problems of heredity. It is, therefore, of interest to pursue the question in greater detail. Glucose and galactose are isomeric aldohexoses, differing only with regard to the relative positions of the groups attached to the fourth carbon in the chain. According to the modern pentaphane ring formulæ for the sugars, it is this carbon atom which is concerned in the γ -oxide ring.



Diagrammatically, the difference between the two sugars may be represented in the plane of the paper somewhat as above. Small as this difference is, it is enough to influence the behaviour of enzymes to the two sugars. Thus, α -methylgalactoside is not hydrolysed by the enzyme which attacks α -methylglucoside. Emulsin, on the contrary, which is well known to be a mixture of several enzymes, attacks the β -glucosides derived from both sugars, and, according to Bourquelot, it acts synthetically to produce either β -glucoside or β -galactoside. Galactose has some influence, though far less than glucose, in hindering the action of enzymes; in other words, it has some power of combining with the enzymes, which are specifically adapted for the derivatives of glucose. These illustrations suffice to indicate how little difference there is between the two sugars, so that it would not be surprising if organisms which were indifferent to one of them could be trained to acquire activity towards it. Only experimental work can help to solve the problem.

Having emphasised the effect produced by differences in the hydrolyte, it is profitable to study similar variation in the enzyme. It is established that the glucosides, which are so widely distributed in plants, are accompanied each by an enzyme able to hydrolyse the particular glucoside. Similar enzymes are found in the seeds. The question arises whether the same enzyme is active in every case. The answer is in the negative, since, in most plants, the enzymes which accompany the β -glucoside in the leaf act only on that particular glucoside, or on closely related glucosides. The seed enzymes, particularly that from the almond (emulsin), do not show these peculiarities, and act on glucosides generally.

The glucosides differ from one another in containing substances, attached to the glucose, belonging to entirely different classes of compounds, and it must be assumed, in view of the behaviour just described, that this radicle has some influence on

the specific enzyme of the plant. Apparently emulsin, which acts on most glucosides derived from β -glucose, is influenced only by the nature of the sugar radicle; it will not hydrolyse rhamnosides. For example, the enzyme of woad (*Isatis tinctoria*) acts on indican but not on salicin; emulsin easily hydrolyses both indican and salicin. Again, the glucoside gaultherin $C_6H_4(CO \cdot OCH_3)(O \cdot C_6H_{11}O_5)$ is not acted on by emulsin in spite of gaultherin being so closely allied to salicin $C_6H_4(CH \cdot OH)(O \cdot C_6H_{11}O_5)$ in structure. The enzyme gaultherase, which accompanies gaultherin in the plant, does not attack salicin, although it hydrolyses gaultherin.

An explanation of these differences is not yet forthcoming; indeed, only a beginning has been made with the problem, but enough has been done to show that there exist a number of closely-allied enzymes, each characteristic of a particular species.

When studying the effect of adaptation on living organisms the most rigorous care is necessary to ensure pure cultures and to maintain them pure during a long series of cultivations. The influence of the medium in which growth takes place is very far-reaching in the case of mixtures of living organisms since the very slightest differences are enough to favour one organism at the expense of the rest. Even though this organism was present initially in a very minor proportion, under the changed conditions it may predominate in a few generations. These considerations are exemplified by the researches of Harden and Penfold (*Proc. Roy. Soc.* 1912, B, 85, 415), which have been already described in this journal. They carry our knowledge of the subject a good deal further, and are of value as suggesting new methods of attack.

When *B. coli communis* is grown in presence of it, little sodium chloroacetate, which inhibits though β , does not prevent growth, a mixture of large and small colonies is obtained. Sub-cultures from the large colonies are usually, though not invariably, found to have lost the power of producing gas from glucose, and a quantitative examination of the products formed indicates an increased production of lactic acid and a diminished production of other products—acetic and formic acids and alcohol. In fine, the selection brought about by the presence of sodium chloroacetate has caused a profound alteration in the chemical changes effected by the organism.

It is suggested by Harden and Penfold that the products normally formed are the result of the co-operation of three enzymes which—

- (1) Convert glucose into lactic acid;
- (2) Form acetic and formic acids and alcohol.
- (3) Decompose formic acid into carbon dioxide and hydrogen.

The treatment has favoured the persistence of an organism containing a large proportion of the lactic-acid forming enzyme. The example is essentially one in which enzymes are destroyed as a result of selection; it would be interesting to see if further culture under increasingly favourable conditions of environment would restore their original powers to the selected organisms.

ANALYTICAL METHODS USED IN INVESTIGATING CARBOHYDRATES IN PLANT TISSUES.

By WILLIAM A. DAVIS, B.Sc., A.C.G.I. (Rothamsted Experimental Station).

METHODS for the accurate quantitative separation of the sugars occurring in plant tissues were first devised by Brown and Morris in 1893 in their classical paper on the "Chemistry and Physiology of Foliage Leaves"; these methods have since been used by other workers, more particularly by Parkin in the study of the sugars of the snowdrop. Whilst the general principle of these methods must be followed by all investigators who wish to obtain an accurate knowledge of the distribution of the sugars in plants, certain serious sources of error in such work have come to light during an investigation of the variation of the carbohydrates in the leaves of the mangold at different periods of the day and night, which has been carried out at Rothamsted by the writer in conjunction with Messrs. A. J. Daish and G. C. Sawyer. A detailed account of this work will shortly be published elsewhere; the following is a brief account of some of the principal points in connection with the analytical methods involved.

The leaf material or other tissue immediately after picking is dropped into boiling 95% alcohol, to which a little ammonia has been added, so as to destroy the enzymes present and prevent any subsequent change in the carbohydrates. The material is then extracted in a large, specially constructed zinc Soxhlet extractor until the whole of the sugars are removed; the residual material contains starch, pentosans, gums, cellulose, etc., and, after drying *in vacuo*, is used for the estimation of these substances. The alcoholic extract is evaporated *in vacuo* in a special simplified distillation apparatus to about 50 to 100 c.c., and is then transferred to a measuring flask and made up to a known volume (250 or 500 c.c.) with water. Small portions (20 c.c.) are then used for determining the *total dissolved dry matter* by evaporating and drying at 100° *in vacuo* in small weighed glass flasks; the remainder is used for estimating the sugars—pentoses, dextrose, lævulose, cane sugar and maltose.

In the estimation of cane sugar serious error may arise unless special precautions are observed. It is necessary for this purpose to invert with a weak acid, such as citric acid, as the use of dilute hydrochloric acid, even under Herzfeld conditions, leads to the hydrolysis of maltose, when present. In our early experiments it was found that by using boiling 2% citric acid, as is usual in such cases, very low results for cane sugar were obtained as compared with the values given by invertase. The reason for the difference was finally traced to the necessity of using relatively large quantities of basic lead acetate for the elimination of tannins, amino-acids, etc., from the original solution; in the removal of the slight excess of lead by means of sodium carbonate, the whole of the acetic acid of the basic lead acetate

was converted into sodium acetate, and this, when present to the extent of 1 to 2%, was found largely, or almost entirely, to inhibit the inversion of cane sugar by boiling 2% citric acid, although without effect on the action of invertase. To effect complete hydrolysis of the cane sugar in such cases it is necessary, after the removal of the excess of lead by means of sodium carbonate, to add a few drops of concentrated sulphuric acid, so as just to change the colour of methyl orange used as an indicator, and then to add citric acid to make a 10% solution. On boiling the solution so obtained for ten minutes, complete inversion of the cane sugar is effected, and numbers are obtained which agree closely with those given by invertase. It is always advisable in working with plant material to estimate cane sugar by both methods, using the results of one method to check those obtained with the other.

In the estimation of maltose by the usual method of hydrolysis, by boiling with dilute hydrochloric acid for three hours, it was noticed that the change of rotation was always about 0.1° less than it should have been for the amount of maltose converted; this had also been observed by others, and attributed to the presence of a hydrolysable substance other than maltose. It was observed, however, in such cases that decomposition had evidently occurred, there being a decided brown humus-like precipitate; and it seemed more probable that the difference of rotation was due to the destruction of a substance with a left-handed rotation, probably lævulose. Special experiments made with cane sugar and pure lævulose fully confirmed this view. Three hours heating in the water bath with 2% hydrochloric acid destroys relatively large quantities of lævulose, to such an extent indeed as to make maltose estimations by this method quite valueless when lævulose or cane sugar is present. Attempts were made to obtain a satisfactory method for the estimation of maltose by hydrolysing the latter with hydrochloric acid at a lower temperature, for example, 70° C., but it was found that it was impossible to effect complete hydrolysis of the maltose without at the same time destroying lævulose, as the former is relatively resistant to hydrolysis and the latter relatively prone to decomposition.

Experiments with the enzyme maltase having given unsatisfactory quantitative conversions, a method was finally devised which gave accurate values for maltose in the presence of the other sugars. Advantage was taken of the well-known fact that certain special yeasts, such as *Saccharomyces marxianus*, *S. exiguus*, and *S. anomalus*, do not contain the enzyme maltase, and are hence incapable of fermenting maltose under conditions in which they completely decompose cane sugar, dextrose and

lævulose. It was found that by inoculating the sterilised solutions of the sugars with pure cultures of these yeasts, kindly prepared for us by Dr. H. B. Hutchinson, every trace of cane sugar, dextrose and lævulose could be fermented away, and every trace of maltase left intact. In dealing with plant materials by such a method it is, however, necessary to introduce a correction for the pentoses present, which, like maltose, are not fermented by the maltase-free yeasts. This correction can be readily made by carrying out duplicate fermentations with ordinary brewer's or baker's yeast, so as completely to remove the maltose also, but leave the pentoses; the difference between the results obtained for the polarisation and reducing power with the maltase-free yeasts and the ordinary yeasts is an accurate measure of the maltose present.

For the *estimation of starch* in plant tissues two methods have been in general use. In the first, the Sachsse method, which has been adopted by the Association of Official Agricultural Chemists of the United States, the starch is hydrolysed to dextrose by boiling with dilute hydrochloric acid for $2\frac{1}{2}$ hours. In the second, due to O'Sullivan, the starch is converted into a mixture of dextrin and maltose by the action of diastase, and the amount of these substances estimated by determining both the rotation and reducing power of the solution. On studying these methods, it was found that, with pure starch, the hydrochloric acid method invariably gives results 4 to 5% too low, owing to a slight decomposition of the dextrose during the prolonged heating with the acid. The method is, too, useless, in the case of most vegetable tissues, owing to the fact that the pentosans present yield pentoses which reduce Fehling's solution and count as dextrose.

With purified starches the diastase method gives sufficiently accurate results; but with plant material low results were obtained which varied considerably with slightly different methods of procedure. It was ultimately found that in such cases considerable error may arise owing to the precipitation and removal by adsorption of a larger or smaller proportion of the dextrin. This loss of dextrin may take place either by adsorption on the finely-divided leaf material, or during the purifying processes after the starch conversion, when small quantities of basic lead acetate have to be added to remove other reducing substances present in the solution with the dextrin and maltose. During the separation of the lead precipitate, and during the precipitation of the slight excess of lead present either by sodium carbonate or hydrogen sulphide, it may happen that a large proportion or the whole of the dextrin is co-precipitated and lost.

In order to avoid this loss of dextrin we have devised a new method for the estimation of starch, based on the conversion of the whole of the latter into the two *sugars*, maltose and dextrose, by means of the special form of diastase known as taka-diastase. This enzymatic material contains not only the enzymes of ordinary malt diastase, but maltase in addition, by which the maltose is resolved, more or less completely according to the conditions,

into dextrose. By carrying out the conversion at 38° the starch of plant materials is converted in 24 hours into a mixture of maltose and dextrose, the latter predominating; no dextrin remains under these conditions, and in the subsequent treatment with basic lead, etc., there is not the slightest loss of sugar to be feared, such as occurs in the case of the colloidal dextrin. It is a simple matter to estimate the relative proportions of maltose and dextrose formed, by measuring both the reducing power and the polarisation of the solution under the standard conditions of Brown, Morris and Millar, and utilising the known values for the pure sugars; the starch then follows from a simple calculation. It is only necessary to observe certain simple precautions, which will be dealt with at length in the complete paper when published.

Modified Admiralty Specification for Oil Fuel.—

A recently published White Paper (D. 7010) gives the following particulars of the modified 1912 specification:—

Quality.—The oil fuel supplied shall consist of liquid hydro-carbons, and may be either:—

- (a) Shale oil; or
- (b) Petroleum as may be required; or

(c) A distillate or a residual product of petroleum, and shall comply with the Admiralty requirements as regards flash-point, fluidity at low temperatures, percentage of sulphur, presence of water, acidity, and freedom from impurities.

The flash-point shall not be lower than 175° F., close test (Abel or Pensky-Martens).

The proportion of sulphur contained in the oil shall not exceed 3.00 per cent.

The oil fuel supplied shall be as free as possible from acid, and in any case the quantity of acid must not exceed 0.05 per cent. calculated as oleic acid when tested by shaking up the oil with distilled water, and determining by titration with decinormal alkali the amount of acid extracted by the water, methyl orange being used as indicator.

The quantity of water delivered with the oil shall not exceed 0.5 per cent.

The viscosity of the oil supplied shall not exceed 2,000 seconds for an outflow of 50 c.c. at a temperature of 32° F., as determined by Sir Boverton Redwood's Standard Viscometer (Admiralty type for testing oil fuel).²

The oil supplied shall be free from earthy, carbonaceous, or fibrous matter, or other impurities which are likely to choke the burners.

The oil shall, if required by the Inspecting Officer, be strained by being pumped on discharge from the tanks, or tank steamer, through filters of wire gauze having sixteen meshes to the inch.

The quality and kind of oil shall be fully described. The original source from which the oil has been obtained shall be stated in detail, as well as the treatment to which it has been subjected, and the place at which it has been treated.

¹ In the case of oils of exceptionally low viscosity, such as distillates from shale, the flash-point must be not less than 200° F.

² Pending settlement of this specification a viscosity of 1,000 seconds was provisionally adopted in 1912.

DYNAMIC ALLOTROPY IN IRON AND ITS ALLOYS WITH CARBON.

By CECIL H. DESCH, D.Sc., PH.D.

I.

THE hypothesis that iron exists in two allotropic modifications was proposed by Osmond and Werth in 1885. Osmond's further work in 1887 distinguished the critical points of the purest iron available, and in 1890 the same author assumed that β -iron was only stable above Ar_3 , and α -iron below Ar_2 . Between Ar_3 and Ar_2 it was supposed that the two modifications co-existed. When it was shown that the magnetic change occurred at Ar_2 , this was regarded as a true allotropic change, so that three modifications were now recognised, γ -iron above Ar_3 , β -iron between Ar_3 and Ar_2 , and α -iron below Ar_2 .

The thermal change $\beta \rightarrow \alpha$ is, however, by no means so sharp as the $\gamma \rightarrow \beta$ change, and some investigators have supposed that miscibility in the solid state occurs between the β and α modifications, so that the transformation of the one into the other goes on gradually. It is not accompanied by a marked change of volume, and scepticism has sometimes been expressed as to the existence of the β -modification. Should the β -range be considered to represent merely a gradual transformation of γ into α -iron, this would be, in effect, a return to Osmond's original hypothesis.

The principal facts to be taken into consideration are:—

1. There is a gradual thermal and dilatometric change corresponding with the β -range, although not necessarily localised at Ar_2 .

2. The magnetic change, as studied by the loss of magnetism on heating, certainly begins at Ac_2 , but the greater part of the magnetism disappears only at a higher temperature, about 900° , that is, at Ac_3 .

3. Rosenhain and Humfrey¹ found that when a strip of pure iron was strained in a vacuum, the temperature varying throughout the length of the strip, a clear difference in the manner of stretching could be perceived between the α and β regions. This fact has not been admitted as a conclusive proof of the existence of β -iron by Benedicks, on the ground that discontinuities in the stretching would occur even if the transition from the softer to the harder iron were a gradual one.

The conception of allotropy has been considerably widened in recent years, largely as the result of the remarkable researches of Alexander Smith and others into the modifications of liquid sulphur. It has been found that the properties of molten sulphur can only be accounted for by assuming that the two liquid modifications, S_γ and S_μ , exist together under conditions of dynamic equilibrium, the equilibrium proportions depending on the temperature. This fact, and similar phenomena relating to phosphorus,

acetaldehyde, etc., have led to a new conception of allotropy as dynamic rather than static. Should two dynamically allotropic modifications, either of an element or of a compound, be mutually soluble, the transformation does not take place at constant temperature, but extends over a certain range.

This conception of mutually soluble modifications has been applied by Benedicks² first to the volume and conductivity changes in silver iodide at about 147° , and next to the case of iron. His view is that β -iron is to be regarded merely as α -iron containing γ -iron in solid solution, the quantity of the latter increasing with the temperature. The transformation of iron beginning near to 900° during cooling thus proceeds in the solid solution, which has such a concentration at about 750° as to have properties sensibly different from those of α -iron.

β -iron has been regarded by many metallurgists, but by no means by all, as a very hard modification, and the hardness of martensite, the principal constituent of hardened steels, has often been ascribed to the presence of β -iron. It is well known that a solid solution is harder than its constituents, an alloy of equal parts of silver and gold, for instance, being twice as hard as either metal separately. On Benedicks' view, the hardness of iron in the β -range is to be ascribed to the presence of γ -iron in solid solution in α -iron. Benedicks further suggests that the well-known change of properties of iron at very moderate temperatures (a minimum of tenacity and hardness below 100° and a maximum at about 250°) may also be accounted for by the formation of two allotropic modifications with a wide range of miscibility.

This interesting question is still under discussion, and two papers dealing with it were read at the spring meeting of the Iron and Steel Institute. One, by Professor Carpenter, contained determinations of the Ar_2 and Ac_2 points in nearly pure iron, tending to show that Ar_2 was not an independent change but, as assumed by Benedicks, the end of the Ar_3 change. The arrest is, however, so small in any case that the experiments have not been regarded as decisive. The second paper, by Dr. Rosenhain and Mr. Humfrey, described tensile tests *in vacuo* which certainly indicated a discontinuous change at the Ar_2 point, indicating that the γ , β and α modifications were quite distinct. The iron used, however, was not free from carbon.

In this position the problem remains. Whatever may be its final solution, it is certain that the conception of dynamic allotropy will prove a most valuable aid in the consideration of the allotropic changes of metals as well as of non-metals, to which

¹ *Proc. Roy. Soc.*, 1909, 83A, 200.

² *Four. Iron and Steel Inst.*, 1912, 2, 242.

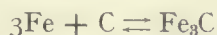
it was first applied. The curiously sinuous curves which represent the changes of many physical properties of metals with the temperature, are strongly suggestive of mutual solubility, over a considerable range of temperature, of allotropic modifications.

II.

The hypothesis of a dynamic equilibrium has also been proposed in order to account for some of the peculiarities of the iron-carbon alloys. In this case it is not the allotropy of a single element, but a chemical equilibrium between a compound and the elements of which it is composed, that is in question; but the phenomena are fundamentally the same, the essential point in each case being an equilibrium between different molecules in solution.

A great stumbling block in the way of a satisfactory theory of the iron-carbon alloys has been the relations of graphite and cementite. In all ordinary steels, and in white cast iron, the carbon is present as the carbide Fe_3C . In grey cast iron, on the other hand, it occurs wholly or partly in the free state, as graphite. Slow cooling of high-carbon alloys favours the formation of graphite; rapid cooling of cementite. Cementite itself, when heated for any length of time, is largely converted into graphite, and many metallurgists have been led to regard the ultimately stable form of all alloys of iron and carbon as a mixture of pure ferrite with graphite. Two assumptions have been made. One, associated with the names of Charpy, Heyn, and Benedicks, is that there is a double equilibrium, a stable one of iron and carbon, and a metastable one of iron and cementite. The other view is that cementite is always the first carbon-bearing product during the cooling, even of grey iron, and that graphite, when formed, always arises from the decomposition of cementite as the temperature falls. This view is due to Wüst and Goerens.

Ruff, in 1911,³ attempted to determine the solubility of graphite in iron at very high temperatures, and found that at $2,200^\circ$ as much as 9.6% was dissolved, and that at higher temperatures the solubility diminished. From breaks in the curve the existence of two carbides Fe_3C and Fe_2C was inferred—a quite illegitimate assumption on the evidence, as the solid phase throughout was assumed to be graphite. The important part of Ruff's explanation, however, was the recognition of an equilibrium

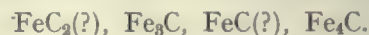


in the liquid solution, the reaction being affected by temperature and by the concentration of the reacting molecules.

Independently, Smits⁴ proposed the same explanation of a dynamic equilibrium between carbon and iron carbide in solution in iron. If the cooling of a molten iron-carbon alloy is rapid, so that graphite fails to crystallise out, the increased concentration of the carbon shifts the equilibrium to the

right; the concentration of the cementite molecules is increased, and when the saturation point is reached cementite crystallises. The details have been the subject of a vigorous controversy between Smits and Ruff.⁵ Both, however, agree in assuming a dynamic equilibrium, and in maintaining the probability that other carbides as well as Fe_3C exist at higher temperatures. The nature of these carbides is not established by Ruff's experiments, as the solid phase was not identified, but was merely assumed to be graphite.

Recently, another remarkable investigation, the full account of which is at present only available in Russian, has become known. Wittorf⁶ has determined the solubility of carbon in iron up to 10% C at $2,380^\circ$, and finds that the solid phases deposited from solution are, in order of falling temperature:



The formulæ have not been inferred from freezing point curves, but from the analysis of micrographically distinct constituents. The, at first sight, improbable order of crystallisation of the carbides is stated by Smits to be thermodynamically possible.

The detailed account of this work will be awaited with great interest. In the meantime, it is clear that other carbides than cementite, Fe_3C , must play a part in the formation of the iron-carbon alloys, whilst the hypothesis of a dynamic equilibrium between elementary carbon and iron carbides, in solid as well as in liquid solutions, is so valuable that it is not likely to disappear from the metallurgy of iron. The alloys of iron and carbon are technically the most important of all, but their constitution still involves mysteries which are only gradually being dispelled by the advance of research.

³ *Ibid.*, 158, 362, 761, 817, 1081.

⁶ *Jour. Russ. Phys. Chem. Soc.*, 1911, 43, 1613.

Iron and Steel Institute.—The following is a list of papers that it is expected will be submitted at the autumn meeting of the Iron and Steel Institute to be held at Brussels from September 1st to 4th:—Armand Baar (Liège), "Reinforced Pile Foundations for Blast-Furnaces"; Professor E. D. Campbell and F. D. Haskins (University of Michigan), "Some Experiments of the Effect of Heat Treatment on the Colorimetric Test for Carbon in a 0.32 Carbon Steel"; Professor A. Campion and J. M. Ferguson (Glasgow), "A Method of Preparing Sections of Fractures of Steel for Microscopic Examination"; Baron E. Coppée (Brussels), "The Manufacture of Coke in Belgium"; General L. Cubillo (Madrid), "The Manufacture of Armour-Piercing Projectiles"; Otto Frick (Beckenham, Kent), "The Electric Refining of Steel in an Induction Furnace of Special Type"; Emil Gathmann (Baltimore), "Commercial Production of Sound Steel Ingots"; Gevers-Orban (Liège), "The Distillation of Tar in Metallurgical Practice"; E. Houbaer (Liège), "The Use of Coke-Oven and Blast-Furnace Gases in Metallurgy"; Professor H. Hubert (University of Liège), "Present Methods of Testing, with Special Reference to the Work of the International Association for Testing Materials"; Baron E. de Laveleye (Brussels), "A Historical Survey of the Metallurgy of Iron in Belgium."

³ *Metallurgie*, 1911, 8, 417, 456.

⁴ *Zeitsch. Elektrochem.*, 1912, 18, 51.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

SOME RECENT ADVANCES IN THE TREATMENT OF WATER WITH HYPOCHLORITES.

By S. RIDEAL, D.Sc., F.I.C.

ALTHOUGH it is only within recent years that the hypochlorites of lime and of soda have been used scientifically on a large scale for the treatment of municipal water supplies, yet to-day there are several hundred townships making use of this steriliser, either as a permanent or a temporary feature, in their water-works scheme. Ideally it cannot be considered so good as the sterilisation brought about by means of either ozonised air or ultra-violet light, since, in the latter case, nothing at all is added to the water, while in the former case the oxygen content is merely raised; but with the proper and regular controls that have been devised and tested for this purpose the sterilisation of water with hypochlorites is more economical in installation, as well as in operation, than either of the other processes. The use of hypochlorites has been shown in all cases to be equally effective in operation, and under special conditions may prove even more efficient and suitable for the purpose.

In the United States of America, the hypochlorite treatment of waters has made great progress, and between 300 and 350 cities there now use the process. One of them treats 30,000,000 gallons per day at a cost of operation of 27·6 cents per million gallons (this includes chemicals, labour and power), while another plant of 15,000,000 gallons per day capacity is run on a cost of 96 cents per million gallons (this includes chemicals, labour, power and supervision).

The method has proved its value in checking water-borne typhoid fever epidemics; portable treatment plants, capable of being sent out and erected in a few hours, are in operation in the States of Indiana, Michigan, Minnesota and Kansas. This procedure compares favourably with the long time required to build, set up, and get into working order any system of efficient filtration. With regard to the actual renewal of bacteria in a water, at the present time it may be generally stated that filtration alone may remove 97% to 98% of the bacterial contamination, while the hypochlorite treatment in conjunction with the filtration removes 99·0% to 99·9%, that is, that the chlorination kills the bacteria which the filtration has left.

How much treatment previous to chlorination any water requires, depends solely on the actual nature of the water itself.

Among the various towns in the United States adopting the chlorine treatment, we find at Cleveland and Erie it is used alone; at Jersey City and Baltimore in conjunction with impounding reservoirs; at Nashville and Omaha with sedimentation basins; at Des Moines with an infiltration system; with slow sand filters at Davenport and Terre Haute; with rapid sand filters at Cincinnati and Cedar Rapids; with mountain streams at North Yakima and Grants Pass; with well waters at Corning.

Mr. C. A. Jennings, of Chicago, Ill., in a paper at the

International Congress of Applied Chemistry, Washington, and New York, 1912, giving a number of valuable statistics, from which the above are taken, has collected data with respect to the influence of this use of hypochlorites on the typhoid fever death-rate, and his results indicate that it is not merely advisable to instal a system of water sterilisation, but it is false economy for any town not to do so. The general result is to decrease the number of typhoid cases by 65% to 45%, and the number of deaths by 50% to 30%.

At Omaha, Nebraska, statistics were kept in special detail. The typhoid cases and deaths had been rather numerous in 1908 and 1909. In the winter of the last year an epidemic occurred which sent the figure to a very high rate of over 240 cases. This was declining in the Spring of 1910, but was still high. In May, 1910, hypochlorite treatment of the water was installed, and the typhoid death-rates per 100,000 for successive years are:—

1908.	1909.	1910.	1911.	1912.
16	26	67	13	about 12

with no autumn recrudescence as formerly.

In England the practice is different to that in the States, since, for some reason or other, the water authorities which, under advice, have adopted this method of treatment have suppressed the information to the public, presumably because they think that the use of a chemical method of treatment casts a slur upon the supply, whereas it should be rather to the credit of an authority that they have adopted such a simple means of ensuring the purity of their town supply. Engineers in England, of course, are not ready to admit that the methods which have been developed during the last hundred years, involving storage and sand filtration, are not perfect, and as there is no such thing as pure water found in nature, it is surprising that the chemist has not been consulted for devising purification methods involving the use of sterilising agents before this.

It would be interesting if the London Water Board would carry out some experiments on the American lines with the Thames water. At Hertford, on the New River, the sewage was treated in this way for some time, but I have not noticed any description of the results in the official reports.

We know, however, that the cost of storage before filtration is so large that the Board would welcome any less expensive method which would ensure the reduction in the number of coli organisms and the death of any *B. typhosus*.

The typhoid organism, when it gets into a water supply, such as a river, tends to disappear with more or less rapidity; this is confirmed by Dr. Houston's investigations on the Thames water. He states, on page 11 of his Ninth Report to the Metropolitan Water Board, April, 1913, that in 29,470 cultures made from 257 samples, *B. typhosus* was only found *twice*, and then only *one* organism in each case. On the same page he gives a very striking table of the typhoid fever death rates per 100,000 in fifteen large northern European cities as compared with fifteen of the largest American cities. The former begin at Edinburgh, population 321,000, typhoid deaths 1·3 per 100,000; and

* * *

conclude with Paris, where the respective figures are 2,750,000 and 5.6. America, on the other hand, has as lowest Cincinnati, 363,591, and a rate of 8.8 per 100,000; rising through intermediate numbers to the appalling incidence at Minneapolis of 58.7 typhoid deaths per 100,000 in a population of 301,408 (McLaughlin, *Boston Med. and Surg. J.*, May, 1912). The last city, by the way, was using raw Mississippi water without any treatment. At the end of 1910 it began, and has uninterruptedly continued, to chlorinate the water, with the result that the typhoid death-rate was reduced 95%. This proves distinctly that the water was responsible for almost the whole of the disease, and that the sterilisation overcame the infection.

But there must be some other factor making the rate so much greater than it is in Europe. The most conspicuous difference is, that in America absolutely crude sewage is so commonly discharged, relying on dilution in their immense bodies of water. This involves the presence of clots of solid matter, faecal and otherwise. If a patho-



CHLORINE DETECTOR.

genic bacillus can find some suitable nidus to live in, the life of a colony may be almost indefinitely prolonged, although its virulence may be reduced.

In Europe, however, even with our greater precautions, it is widely known that faecal residues are apt to enter rivers; therefore, in my opinion, the practice of sterilisation is necessary for us as well as for the American.

In a previous article I have discussed the excess lime method, which is one of the alternatives put forward by Dr. Houston, but it would seem that the practical difficulties in carrying this method out would be very great.

Since the question of quantity as well as quality enters into so many cases where a river supply is used, it by no means follows that the heavy cost involved in storage of flood waters may not have to be faced in many instances, but for relatively small populations on large rivers there can be no doubt that the use of chlorine as a steriliser is both economical and rational, and no town adopting this method of treatment need be ashamed of having had recourse to it.

In my practical experience of this process of sterilising water I have found that the objections were either imaginary or owing to careless methods of dosage. Seeing that there are now so many appliances by which the ratio of the sterilising agent to the volume of the water pumped from the river or drawn on by the town can be automatically adjusted, there is no reason why any excess of chlorine should ever be found in a public supply.

My son and Mr. Evans recently at the Society of Public Analysts described a little instrument, based upon the de-polarising action of any free oxidising agent in the water on a platinum-copper couple, which will determine very minute quantities of available chlorine in a water. One part of available chlorine when present in 10,000,000 parts of water may be easily detected by this method. The detector may be placed anywhere along the line of the mains in order to note the absorption of the chlorine by the water in its course through the pipes, and may also be used by an inspector in following up complaints. By this means, a very accurate control may be kept on the amount of dosage necessary for the efficient sterilisation of a water supply, and any chance of excess of reagent being left in the water will be entirely avoided. As a matter of fact, an excessively chlorinated water becomes undrinkable a long time before the amount of chlorine in it may be considered injurious.

OILS, FATS, AND MILK PRODUCTS.

By E. RICHARDS BOLTON and CECIL REVIS.

To those interested in the question of hardened fats the recent paper of Bedford and Erdmann (*J. Prakt. Chem.*, 1913, 87, 425) will be of great interest. It appears from this work that the oxides of nickel will replace the actual metal and at the same time render the process simpler and easier. In fact, it appears that the actual value of nickel as a catalyst is probably due to the presence of a small quantity of oxide. This method of hydrogenisation has advanced so far that an experimental plant is now in existence by which a great number of different oils have already been treated.

Incidentally it may be noted that a company has been started at Fredrikstad with a capital of £166,700 to work a new German method of refining whale oil; large quantities are to be submitted to a hydrogenisation process, and the plant is expected to deal with some 300 barrels of oil per day.

Grimme (*Chem. Rev. Fett. Ind.*, 1913, 20, 129) has published analyses of two samples of hardened marine animal oils, both of which show very great reduction in iodine value and greatly enhanced melting points (viz., 47.2 and 38.5° C.) and iodine values (Wijs) 23.2 and 58.3.

He states that these hardened oils give characteristic colourations with nitric, sulphuric, and phosphomolybdic acids, and also with sodium hydroxide.

The disturbing effect of hydrogenisation on some of the constants and chemical tests for oils has brought into great prominence various methods of detecting minute traces of the various metallic catalysts used, and the original work of Tschugaeff (*Ber.*, 1905, 38, 2520) has been developed in various ways for the purpose of detecting nickel, with a result that the metal can now be detected with almost as great delicacy as arsenic.

Petrusi and Gastaldi (*Chem. Zeit.*, 1913, 37, 609) are responsible for a new test for hydrocyanic acid, which they claim will detect less than one part in 10,000 of HCN. This method seems to present certain possibilities with regard to

the detection of small quantities of hydrocyanic acid in oil-bearing seeds, and is worthy of examination by those interested in this subject.

A curious effect has been noted by Schindler (*Z. öfentl. Chem.*, 1913, 19, 132) of certain edible oils upon tanks lined with an alloy of lead and antimony; in certain cases it seems that sufficient lead may be removed as lead soap to cause pronounced turbidity in the oil; notably Sesame oil appears to possess this power to a considerable extent.

When oils containing unsaturated glycerides are heated with solutions of selenious acid, they undergo some remarkable changes, as has been shown by Fokin (*J. Russ. Phys. Chem. Soc.*, 1913, 45, 285); particularly is this the case with castor oil, as though the oil undergoes a reduction in iodine value, there is also a considerable reduction in saponification value, and the product also contains selenium.

Some very useful determinations by Hehner's method for stearic acid have been carried out by Heiduschka and Burger (*Zeit. öfentl. Chem.*, 1913, 19, 87), confirming Hehner's original researches by this method, and they have also extended it to the determination of palmitic and myristic acids, and have worked out very carefully the practical considerations which it is necessary to take into account. As might however be expected, the presence of stearic acid is fatal to the determination of palmitic or myristic acids when present together.

The melting point and solidifying point of fats, while extremely useful in analytical work, must always impress the observer with their extremely empirical nature, and some interest therefore attaches to a paper by Le Chatlier and Mlle. Caraignac in the *Comptes Rendus*, 1913, 156, 589. Working with cocoanut oil and "stearine," these authors have shown that the change of state on melting is an ordinary reversible chemical change, but of very slow character, and they also show that the melting point of fats is very much less liable to vary on account of the external conditions than is the case with the solidifying point. In passing, we may note an attempt which has been made by Bömer and Limprich (*Zeit. Untersuch. Nahr. Genussm.*, 1913, 25, 354) to elaborate a nomenclature for mixed glycerides which has arisen out of their work on this subject.

From time to time the analyst is brought face to face with extraordinary results given by various kinds of butter. Undoubtedly quite abnormal figures do occur in quite genuine samples, and it is often with great difficulty that these are accounted for. A considerable amount of information on the subject has been collected by Beerbohm in the *Milchwirtschaftliches Zentralblatt*, 1913, 42, 257, of the various influences which affect the analytical figures given by butter fat.

Among milk products we may note that Burri (*Molkerei. Zeitg. Hildesheim*, 1913, 27, 81) has published an analysis of a whey-lemonade known as "Molkina," which appears to be largely a sweetened acidified whey, aerated with carbon dioxide, and which may be prepared from rennet whey or, in the case of a sample analysed by Kostler, from acid whey.

Kindraczkw (*Oesterrich Molkerei Zeitg.*, 1912, 19, 257) describes a Carpathian sour milk somewhat similar to Yoghourt and called "Huslanka." This product is characterised by extraordinary keeping properties, and some special variety of *B. bulgaricus*, called by the author *B. carpathicus*, and stated to form pure levo-lactic acid, appears to be the active agent.

Lengthy investigations into the bacteriology and composition of Yoghourt have been made by Raebiger (*Landwirtsch Mitteil. f. d. Prov. Sachsen*, 1912, S. 21), and by Griber (*Zeit. Untersuch. Nahr. Genussm.*, 1912, 24, 541), and the

latter has obtained some interesting results with seventeen commercial preparations, and has set out some ideas as to the control of the sale of such preparations. In view of the extraordinary mixtures which are sold as Yoghourt, and of the still more extraordinary cultures for preparing them, some such standardisation is eminently necessary.

Hastings, Evans and Hart (*Cent. f. Bakt. Abt. II.*, 1913, 36, 443) have published an interesting continuation to their already valuable work on Cheddar cheese. It appears clearly, as a result of the excellent work of the Wisconsin Experimental Station, that the whole process of ripening Cheddar cheese is to be ascribed to *B. acidi lactici* alone, and this last work contains remarks on the bearing of these results on the chemistry of Cheddar cheese ripening.

A summary of the systems of the manufacture of milk sugar has been made by Pedersen (*Journ. New Zealand Dept. Agri.*, 1913, abs. *Journ. Soc. Chem. Ind.*, 1913, 32, 247), which contains useful details of the methods employed in Germany and Sweden.

In conclusion we may draw attention to a lengthy dissertation on the subject of preservatives which has been made by Bokorny (*Cent. f. Bakt. Abt. II.*, 1913, 37, 168).

TITANIUM AND ITS USES.

By SYDNEY J. JOHNSTONE.

DURING recent years considerable development has taken place in the commercial utilisation of titanium and its compounds in the steel, textile and other industries. Despite the fact that the metal was isolated by Berzelius so far back as 1825, by the reduction of potassium fluorotitanate with potassium, its utilisation on an important commercial scale may be said not to have started more than five years ago, although certain of its compounds had previously found a limited use in the dyeing industry.

Titanium is often described as being one of the rare elements, but this is incorrect, as it is a frequent constituent of iron ores, clays, and many igneous rocks, particularly those of a basic nature. According to the estimate of one authority titanium is one of the ten most common elements found in a state of combination on the earth's surface. In the mineral kingdom this element most commonly occurs as the dioxide (TiO_2), either alone, as the mineral *rutile*, or in combination with ferrous oxide as *ilmenite*; less common titanium minerals are *brookite*, *sphene*, *giekielite*, *picroilmenite*, *strüverite*, etc. In addition to these minerals there exists in many localities large deposits of iron ore containing from 2 to 30% of titanic oxide.

As already mentioned, metallic titanium in the form of its ferro alloys is now finding widespread use in the steel industry, due to its great affinity for oxygen and nitrogen, titanium being one of the very few elements that combines directly with the latter gas. The function of titanium in steel manufacture is not to give new properties to the product, such as, for example, do tantalum, nickel, chromium and manganese, but to act as a scouring agent in removing minute traces of certain substances, such as slag, nitrogen, and metallic oxides, which exert a deleterious effect on the wearing properties of finished steel.

Much evidence has been adduced during recent years that brittleness in steel is to some degree caused by the presence of nitrogen, and it has been demonstrated by E. von Maltitz that Bessemer rolled steel which contained 0.014% of nitrogen was greatly improved, physically, by treatment with ferro-titanium, and the nitrogen content was thus reduced to 0.005%. The beneficial effect of ferro-

titanium in preventing segregation of phosphorus, sulphur and silicon, has been amply proved by the exhaustive experiments of G. B. Waterhouse.

In the steel industry titanium is generally employed in the form of a ferro alloy, containing from 10 to 25% of titanium. Alloys containing over 25% of the metal are difficult to use, owing to their high fusion point rendering them difficultly soluble in the molten steel. The ferro-titanium can be prepared from titaniferous iron ore, the usual raw material employed, by two general methods, according to the nature of the product desired. The first process, due to A. J. Rossi, which gives a product high in carbon, consists in heating a mixture of finely pulverised titaniferous iron ore and charcoal in an electric furnace of the Siemens type to a temperature of not less than $1,927^{\circ}\text{C}$. Alloys on the market prepared by this process contain from 10 to 15% of titanium, 5 to 8% of carbon, and the balance, iron. According to a recent patent specification by the same inventor ferro-titanium carbide is equally efficient for the final purification of steel, and can be produced at a lower cost. An alloy of this type now on the market has the composition: titanium, 17.79%; carbon, 7.46%; silicon, 1.41%; and aluminium, 0.80%.

If an alloy free from carbon is desired, then the reduction must be performed by some substance other than carbon, and for this purpose aluminium has been found to be very suitable. The process is, briefly, as follows: A quantity of scrap aluminium is melted in an electrically heated furnace, and into this bath is charged either scrap iron or iron ore, which yields a layer of iron upon which the aluminium floats. The requisite quantity of titanium ore is next added, and is immediately reduced by the molten aluminium and forms an alloy with the iron. As the reaction is exothermic, little current has to be supplied to maintain the bath at reaction temperature.

The alloy which finds most general use is one containing from 10 to 15% of titanium, about 10 lbs. of the alloy being added for each ton of steel. The alloy, which is usually added as the steel runs into the ladle after recarburisation, causes the impurities to rise to the surface, and is itself oxidised and passes to the slag; thus, in the finished steel hardly a trace of the titanium remains. Treatment with ferro-titanium has been applied with considerable success to Bessemer, open hearth and crucible steel, and also to cast iron intended for special purposes. The gradually increasing use of these alloys in steel manufacture is ably demonstrated by the fact that in the United States alone over 410,000 tons of titanium treated steel was produced in 1911, whereas the quantity so treated in 1909 and 1910 was 35,945 and 195,940 tons respectively. Titanium-thermit, consisting of an intimate mixture of titanic oxide and metallic aluminium, is sometimes employed for the same purposes as ferro-titanium.

Alloys of titanium, with metals other than iron, are employed to a small extent, and these have similar properties to ferro-titanium. An alloy of copper containing 5 to 12% of titanium is used to improve copper castings; the addition of from 1 to 2% of the alloy enables the metal to be cast in sand without difficulty, giving a casting of dense structure free from blow-holes.

A small quantity of ferro-silico-titanium is made for use in the steel industry, when it is desirable to add silicon in the final stages of manufacture.

In the textile dyeing industry titanium salts, particularly the lower chloride, TiCl_3 , and sulphate, $\text{Ti}_2(\text{SO}_4)_3$, are gradually finding an extensive use on account of their great power as acid-reducing agents.

In the dyeing of cotton goods with direct colours it sometimes happens that the colour obtained is uneven or too deep, and it becomes necessary to "strip" the colour and re-dye the goods. Experience has shown that this "stripping" can be performed in a few minutes by immersing the goods in a solution containing titanous chloride or sulphate equal to about 5% of the weight of material to be treated. There are, however, certain dyes, such as Primuline yellow, Thioflavine S, which cannot be "stripped" by this means, and in some cases the action is somewhat slow, as with paranitraniline red and naphthylamine claret.

Titanous chloride is also employed in laundry work for the removal of iron stains and for clearing the whites of fancy coloured goods that have "run" in the wash.

Titanous chloride, which comes on the market in the form of a 20% solution, can be prepared by electrolytically reducing a hydrochloric acid solution of titanium hydrate in the cathode compartment of a divided cell with a lead electrode. The anode employed usually consists of carbon plates in dilute hydrochloric acid.

In the tanning industry potassium titanium oxalate has for some time past been used for mordanting leather, and more recently, the titanium lactates, introduced by Dr. Dreher, of the Freiberg Tanning School, have found widespread application. As titanium salts readily form "lakes" they can be utilised in this connection either as mordants or "strickers."

In the first case, they are applied to the leather before the dyestuff, and serve to fix it, and in the second case, they develop and intensify the colour already in the skin. The titanium lactates are prepared in various forms and come onto the market under the name of "Corichrome."

As mordants for animal fibre, various titanium salts find a somewhat limited application.

The question of the economical smelting of the previously mentioned titaniferous iron ores, of which large supplies are available, is one which has received considerable attention. The chief difficulties encountered under the ordinary working conditions of the blast furnace are the formation of a pasty slag and of aggregations of titanium cyanide and nitride in the higher portions of the furnace. It has been clearly shown, however, by the numerous experiments of A. J. Rossi and others, that good iron can be economically produced from these ores, and it is stated that the iron ore from the Adirondack Mountains, New York State, which was successfully smelted for twenty years, contained from 9 to 15% of titanic oxide. Attempts in the United Kingdom to smelt iron ores containing high percentages of titanic oxide have, however, been mostly abandoned soon after starting. At the present time it is very difficult to negotiate a sale, in this country, of iron ore carrying over 2% of titanic oxide.

In the United States during the past few years titanium compounds have received some attention as illuminants. The "magnetite" arc lamp which is used to some extent has its positive electrode composed of a mixture of magnetite and chromite, together with 15 to 20% of ilmenite. The lamp has the disadvantage of being capable of use only on a direct current circuit.

Amongst the various uses for titanium that have been suggested may be mentioned its employment for the fixation of atmospheric nitrogen, and as a constituent of a non-cerium pyrophoric alloy, containing also manganese, antimony and chromium.

MOLECULAR PHYSICS.

By J. A. CROWTHER, M.A. (Fellow of St. John's College, and Demonstrator in Physics in the Cavendish Laboratory, Cambridge.)

CHAPTER VI. (*continued*).

THE CHEMISTRY OF THE MODEL ATOM.

THE analysis becomes simpler, and leads to the same general results, if we consider the electrons confined to a single plane instead of being able to move in three dimensional spaces, a supposition which is not altogether without justification on experimental grounds. This case has the further advantage that it can be studied experimentally in a variety of ways. Of these the very beautiful experiments of Mayer, though designed for quite other purposes, are perhaps the simplest to reproduce.

A large number of needles are magnetised together in a solenoid, and are floated vertically in a basin of water by pushing all their (say) north poles into small corks, their south poles being at the same depth below the water. These latter repel each other, just as do the electrons, according to an inverse square law. To represent the action of the positive sphere we may place a strong electro-magnet beneath the bowl with its north pole upwards. It can be shown that the attraction of this magnet for the tiny south poles is (for the horizontal plane in which alone they are able to move) approximately proportional to their distance from a point immediately above the pole. Fig. 20 is a photograph showing ten of these small magnets. It will be seen that they are arranged in two rings of seven and three respectively. The attracting electro-magnet is concealed below the board.

On making the experiment it is found that the greatest number of magnets which we can have in an empty ring is five. If a sixth is added the ring breaks up, the magnets gradually settling down into an arrangement of five on the outside with one in the middle. The number which must be placed in the middle rapidly increases with the number in the outer ring. Thus an outer ring of twelve requires at least eight inside, and one of thirty no less than one hundred and one for stability to be possible. As these inner magnets are subject to exactly the same laws as the outer ones, the whole system, whether of magnets or electrons, splits up into a series of concentric rings, with a perfectly definite number of particles in each.

A complete mathematical solution has been obtained by Professor Thomson. Table VI. contains his results for the model atoms in which the number of electrons is not more than fifty-two. I would point out very emphatically at this point that no stress must be laid on the exact numbers given in this Table. The simplifications we have made are too many to render it even possible that these arrangements represent actual atoms of any

real substance. Neither does the weight of the argument rest on any numerical relations between the numbers of electrons in the different rings. The general law of electron grouping enunciated above when discussing three dimensional systems is amply sufficient for all that follows, and is all we have at present any right to make. It is, however, of the greatest assistance in following the arguments to clothe our abstract principles in concrete form and to consider some definite case where the relationships can be expressed in numerical form. The system chosen is the simplest for the purpose.

The first row in Table VI. contains, with these limitations, the "atoms" for which there is only one ring of electrons, the second those with two, and so on, the upper number being in each case that contained in the outer ring. Thus 11, 5, 1, which commences series C, implies that this atom contains an outermost ring of eleven electrons with an inner ring of five and a single electron at the centre.



FIG. 20.—A "MODEL" ATOM.

Remembering that the number of electrons in the atom is proportional to the atomic weight, it will be seen that this Table represents a series of model elements arranged according to their ascending atomic weight.

A very cursory glance at this Table at once reveals a very striking similarity to Mendeleef's periodic classification of the elements. Thus, for example, if we assign any chemical or physical property to the existence in the atom of an arrangement of electrons such as (5, 1) this property will disappear as we pass along the series to atoms with

different groupings, and consequently different properties. Proceeding still further, however, we come to a place where the original grouping (5, 1) is restored with the addition of an extra outer ring of eleven electrons (11, 5, 1).

This grouping again disappears as we pass along series C, to reappear again with an extra ring of fifteen at the beginning of series D, and with a further ring of seventeen in series E.

Thus any property associated with a given grouping of electrons will recur again and again at intervals, as the number of electrons in the model atom is increased. It can hardly be necessary to point out how closely this resembles the arrangement of the elements according to atomic weight where the properties of the element sodium, for example, disappear as we proceed to elements of higher atomic weight, only to make their appearance again

aluminium, to be replaced by acid ones at sulphur and chlorine. As we proceed further, however, there is a sudden recurrence of the alkaline properties at the next element, potassium.

Again, although the groupings shown in the Table are all stable, they are not the only possible arrangements of electrons. Thus, while we cannot have a ring of six electrons unless there is at least one electron inside it, we may conceivably have more than this without disturbing the equilibrium. Thus an atom with ten electrons might be represented either by (8, 2) as in the Table, or by the grouping (7, 3). The latter grouping is the one actually seen in the photograph (Fig. 20). In general, one of these arrangements would be more stable than the other, that is to say, its energy would be greater and it would be more likely to survive. At certain points, however, the different configurations might be so

TABLE VI., SHOWING STABLE ARRANGEMENTS OF ELECTRONS IN A POSITIVE SPHERE OF ELECTRICITY.

A	1				2	3			4			5			
B	5 1	6 1	7 1		8 1	8 2	8 3		9 3	10 3	10 4		10 5		11 5
C	11 5 1	11 6 1	11 7 1	12 7 1	12 8 1	12 8 2	12 8 3	13 8 3	13 9 3	13 10 3	13 10 4	14 10 4	14 10 5	15 10 5	15 11 5
D	15 11 5 1	15 11 6 1	15 11 7 1	16 11 7 1	16 12 8 1	16 12 8 2	16 12 8 3	16 13 8 3	17 13 9 3	17 13 10 3	17 13 10 4	17 14 10 4	17 14 10 5	17 15 10 5	17 15 11 5
E	17 15 11 5 1	18 15 11 6 1	18 15 11 7 1	etc.											
	s	t													

with slight modifications when we arrive at the element potassium.

There are many other resemblances which may be pointed out between the periodic Table and our scheme of electrons. In the first place it will be seen that in the same group the atoms of series D and E have four rings in common with each other, while those in series B and C have only two. The elements of higher atomic weight will resemble each other more closely than the elements of lower atomic weight. This again is a commonplace of the periodic classification. Further, it will be seen that at certain places in the Table the groupings are in rapid change, while at others the configuration alters much more slowly. This again corresponds very closely with what actually occurs in the arrangement of the elements where starting, for example, at sodium, the alkaline properties gradually disappear as we pass through magnesium and

evenly balanced as to be almost equally stable. In this case we should have a series of elements of almost exactly the same atomic weight, but differing somewhat, though probably not markedly, in properties; a case corresponding very closely to the puzzling series of rare earths which occur in the middle of the periodic Table.

It may be asked, what properties can be associated with a grouping of electrons in a sphere of positive electrification? If we are on the right track, we may expect sooner or later to be able to interpret every phenomenon associated with the atom in terms of such a system. But this is a far cry, and it must be confessed that our present knowledge does not extend very far in this direction. We can, however, suggest several important properties which may, and one or two which can be proved to be due to causes of this kind.

In the first place, we may almost certainly

include all those forces of cohesion, adhesion, and the like, which go by the name of molecular: those attractions which, quite insensible at any appreciable distance, are yet at distances comparable with the diameter of a molecule strong enough to rivet together the atoms and molecules in a solid so firmly that in some cases it requires stresses of many tons to the square inch to drag them asunder. Since these molecular forces determine tenacity, elasticity, and melting point for solids, and surface tension and vapour pressure for liquids, it will be seen that a very considerable and important set of properties are thus brought within the scope of our hypothesis.

The most probable and, indeed, at present, the only explanation of these molecular attractions, is that they represent the resultant force between the different parts of the two electrical systems which make up the atoms, each of which is neutral as a whole. Let us take as an illustration a very simple concrete case. Suppose the black dots in Fig. 21 represent the outer rings of electrons in two adjacent atoms, and that the effect of the positive



FIG. 21.—DIAGRAM TO ILLUSTRATE COHESION.

electricity around them may, for the sake of simplicity, be regarded as concentrated in the white circles between them.

Since each of the atoms, as a whole, is electrically neutral, the attractions and repulsions between the different parts at any distance which at all greatly exceeds the diameter of the atom will be vanishingly small. If, however, as in the illustration, the two atoms are brought so close together that their distance is only a fraction of this diameter, this is no longer the case. It can readily be shown that the atoms will turn so that a negative electron in the one is faced by the positive portion of the other. There would thus be an attraction between them which would increase with great rapidity as the distance between the atoms was diminished. The law of force would thus be similar to that actually found for these molecular forces.

The magnitude of the forces obviously depends on the number and arrangement of the electrons in the atom. A complete theory of cohesion is not possible in the present state of our knowledge. There is little doubt that it will be found to proceed on lines not very different from the explanation suggested above.

Although our methods of analysis do not enable us to pursue this problem further, another very important characteristic of the atom, namely, its emission spectrum, has proved more amenable to investigation. The evidence obtainable from a study of spectral lines is so important that we shall deal with it more fully in a later chapter. For the present it may be noted that, before the electron

had been isolated and its properties determined by direct experiment, it had been shown by Lorentz that the systems emitting the vibrations which constitute ordinary light were negatively charged particles, and further, that the ratio of the charge to the mass was of the order of 1.7×10^7 . It was also shown that these same electrons were the cause of the absorption of light and its dispersion in transparent media. Thus, practically the whole range of optical phenomena of the atoms are due to the electrons which they contain.

This point is so important that we shall return to it in a separate chapter. In the remainder of the present chapter we will confine our attention to that important, fascinating and mysterious quality of the atom which determines its chemical properties, namely, valency.

Ever since the time of Berzelius, the view has been held that the forces binding the different atoms together within the molecule were electrical in their origin, that, for example, the molecule NaCl was formed by the mutual attraction of a positively charged sodium atom for a negatively charged atom of chlorine. This view was, of course, based on the phenomena of electrolysis. When an electric current is passed through a solution of sodium chloride in water, it is found that the sodium makes its way to the negative electrode, the chlorine to the positive. Thus, the salt behaves as if the sodium atoms bore a positive charge and the chlorine a negative. The conclusion seems irresistible, that the force binding together these opposites in the same molecule is the electrical attraction between their charges.

It was found necessary, from consideration of the electrolysis of such compounds as CuCl_2 , etc., to assume that the atoms of certain elements carried charges amounting to twice, three times, etc., the charge carried by a sodium or chlorine atom, and thus the notion of valency arose, the valency of the element being the number of times its charge in the ionic state exceeded that of sodium or chlorine. For elements such as carbon and nitrogen, which are never found in the free ionic state, the valency was deduced from their chemical analogy to elements of known valency. We may say, then, that positive valency represents the tendency of the neutral atom to part with its electrons, while negative valency is the tendency of the neutral atom to absorb electrons into itself from without. If electro-positive and electro-negative atoms are present together, these tendencies can both be satisfied by the mutual interchange of one or more electrons. The passage of an electron from one atom to the other will make the former positively the latter negatively charged, and the attraction of the positive atom for its lost electron will constitute on our hypothesis the force of chemical combination between the two atoms.

Although these ideas in one form or another are as old as Davy and Berzelius, chemists have made, up to the present, little direct use of them, finding the notion of bonds of affinity sufficient for all practical purposes. So long as the electric charge was regarded as something apart and distinct from

the atom itself, something of a different nature superadded to it, by external means, the electrical theory, except in so far as it explained the phenomena of electrolysis, in which it had its rise, was no more fundamental than the theory of a mysterious chemical bond.

With the electron theory of matter, the situation is quite changed. It is evident that the question whether a given atom will tend to lose or gain electrons, and how many electrons can be so lost

or gained, will depend upon the number and arrangement of the electrons within it, and the forces with which they are retained in the atom. If we can determine these, and if we can show that they lead to a similar distribution of valency with atomic weight to that actually demanded by chemical considerations, we shall feel that we have made a very hopeful start in the solution of this fundamentally important question.

(To be continued.)

CHEMICAL ENGINEERING.

THE PYROPHORIC ALLOY INDUSTRY.

By GEOFFREY MARTIN, Ph.D., M.Sc., F.C.S.

SOME thirty years ago Auer von Welsbach founded the rare earth industry by utilising thorium and cerium oxides for the manufacture of incandescent mantles.

Quite recently a new industry has developed out of this older industry, namely, that of the so-called "pyrophoric alloys." These possess the extremely remarkable property of giving rise, when struck by a sharp or hard surface, to such a copious abundance of brilliant sparks, that cigars, cigarettes, gas and other combustible substances may be readily lighted by their aid. These alloys have now been placed on the market as a more or less successful substitute for matches, and the new industry is making rapid headway.

The originator and moving spirit of this new industry was again Auer von Welsbach, and the discovery arose in this manner:—

It is well-known that practically the sole commercial source of the thorium for incandescent mantles is monazite sand, which is a mixture of the phosphates of the rare earth metals, having the following composition:—

				%
ThO ₂	..	..	..	5—7
Ce ₂ O ₃	..	..	..	25—35
La ₂ O ₃	}	..	..	20—30
Pr ₂ O ₃				
Nd ₂ O ₃				
Y ₂ O ₃	..	..	..	1—5
P ₂ O ₅	..	..	..	25
SiO ₂	..	..	..	1—4

It will be seen, therefore, that in this substance only a relatively small proportion of thorium is present—5 to 7%—the rest consisting of rare earths of the cerium group. Now the mixture of rare earths which gives the brightest light to an incandescent mantle consists of 99% thoria and 1% ceria, and consequently for the purpose of incandescent mantle manufactures all the thorium is extracted from the monazite sand, but there remains over a great bulk of useless rare earths, amounting perhaps

to 75% of the whole, and consisting of Ce₂O₃, La₂O₃, Pr₂O₃, Nd₂O₃, etc. In fact, outside the thoria factories little mountains of these waste rare earth oxides have accumulated in the course of years, and as about 3,000 tons of monazite sand is now worked up yearly for thorium, it will be readily understood that the profitable utilisation of thousands of tons of these waste earth residues has long been a pressing industrial problem.

Welsbach turned his attention to the matter, and in 1903 made the discovery on which is based this new industry. From the waste cerium residues he prepared the metals by the electrolysis of the fused alkali chlorides, using as negative pole a piece of iron wire. On this he obtained a lump of metal,



FIG. 1.—SIMPLE PYROPHORIC ALLOY GAS-LIGHTER.

which he then began to cut away with a knife. He now observed that the outer layers of metal, which consisted of practically pure cerium, cut away without any "sparking" effect, but that as he approached the inner core of iron a vivid display of sparks attended the cutting operation, and that, moreover, the nearer he approached the internal iron core the more pronounced became this effect. On investigating the matter he traced the "sparking" effect to the presence of iron in the cerium metals, the outer non-sparking layers consisting of iron-free practically pure cerium metals, while the internal layers were more and more contaminated with iron the nearer the central iron core was approached.

Perceiving the industrial possibilities of this chance observation, Welsbach at once set to work to prepare a series of alloys of the cerium metals with iron. He found that the greater the percentage of iron in the cerium metal the more pronounced

is its property of giving an array of bright sparks when scratched or rubbed, the effect reaching a maximum with alloys containing 30% of iron. Similar effects were exhibited by alloys of nickel or cobalt with the cerium mixed metals—as the mixture of metals obtained by reducing the mixture of rare earth oxides left over after the separation of thorium is called—and in 1903 he took out his famous patent D.R. Patent, No. 154807, Klasse 4e (July 31st, 1903); British Patent, 16853/03.

Welsbach succeeded in selling this patent to the Pyrophoric Metalgesellschaft A.G. of Köln-Braunsfeld for the large sum of 600,000 m. (£30,000) and also disposed of the foreign rights on advantageous terms, the English rights being secured by the British Pyrophoric Metal Co., of Leeds.

No sooner, however, had these new companies begun to successfully put these "firestones" on the market when difficulties arose. In Germany, as in other countries, a new terror to civilisation has arisen in the clever "patent" lawyers, whose business it is to discover flaws in the patents of profitable inventions, and soon the Pyrophoric Metalgesellschaft was involved in the throes of most expensive litigation with rival companies, with the result that the patent was in part upset. Welsbach, however, who was under no obligation to return the purchase-money if this patent was upset, obtained, what few inventors do, the full profits of his invention.

It should be particularly noted that for the manufacture of these alloys pure cerium is never used, but "technical cerium" or "cerium mixed metals," which consist of an alloy of rare earth metals, consisting mainly of cerium, but containing a considerable amount of lanthanum, praseodymium, didymium and neodymium. Although a considerable sparking effect is attainable with alloys containing anything between 10 and 65% of iron, the alloys usually sold for the purpose contain about 35% of iron and 65% of the cerium mixed metals. The cerium mixed metal is usually obtained by the electrolysis of the molten chlorides, but every precaution has to be taken to exclude air, as the metal is extremely oxidisable. Cerium, in fact, is one of the most reactive metals known. It absorbs hydrogen and nitrogen quite readily, while when heated in an atmosphere of carbon dioxide or carbon monoxide it simply decomposes them, extracting their oxygen and depositing carbon. Consequently it is impossible to obtain a gaseous atmosphere (if we except the argon group of elements) indifferent to cerium. So reactive is it that it unites with antimony and arsenic with a violent explosion, and the temperature is so high that the bottom of the porcelain crucible melts, allowing the white-hot alloy to pour through in a blazing condition. Cerium, therefore, is a difficult substance to work with, and so only five years ago the cerium alloys were high in price. By means of processes, which naturally are kept secret, the manufacture has been so improved recently that the British Pyrophoric Metal Co. of Leeds is now putting the alloys on the market at 42s. 6d. per lb.

The alloys of the cerium mixed metals with iron

are usually known as "Auer-metal" sometimes as "cerium-iron," and for hardness or durability in air are among the best of such preparations. However, this "auer-metal" soon encountered a serious rival in the "Kunheim" metal, which was cheaper and lighter. This latter alloy was patented by the firm Kunheim & Co. (Patent K. 39885, Kl. 78f. January 25th, 1909), advantage being taken in this patent of the fact that the cerium metals readily combine with hydrogen to form hydrides. First of all an alloy of the mixed cerium metals is made with magnesium and aluminium, and then this is heated in an electrically heated muffle furnace to a temperature of 500° C., while a stream of hydrogen is passed over the surface until no more is

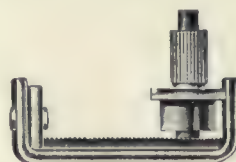


FIG. 2.—SIMPLE PYROPHORIC GAS-LIGHTER (END SECTION).

absorbed. Finally the alloy is allowed to cool in the stream of hydrogen gas. The quantity of hydrogen taken up corresponds to the complete transformation of the cerium metals into hydrides, 1 gm. of the alloy absorbing 130 to 150 c.c. of H gas. By means of this "hydrogenation" process the magnesium-cerium alloy is made very reactive as a sparking agent, and without this treatment the alloy seems to be technically unsuitable for the purpose. It is a curious fact that whereas the pure hydrides of the individual cerium metals rapidly oxidise in the air (and so become useless) and also lose a great part of their hydrogen at a red heat, yet the mixture of metals yield hydrides so stable that they can be heated in air to a red heat without losing much hydrogen. Also the temperature at which the mass is treated with hydrogen is very important since the stability of the alloy in air is largely affected by this.

The composition of one of these "Kunheim" pyrophoric alloys is given as follows:—

	%
Cerium	36
Other cerium metals	49
Magnesium	10
Aluminium	1
Iron	0.5
Silicon	0.5
Hydrogen	1.3
Traces of Be, Zr, Ti, etc.	



The cause of the sparking is generally attributed to the fact that the cerium metals are readily oxidisable and, when heated, burn. When a piece of an alloy is struck with a sharp or hard surface, small particles are knocked off, and the heat of friction raises these to their ignition temperature, and they fly off, burning brilliantly. The reason why the pure, individual metals do not show this

FIG. 3.—CIGARETTE-LIGHTER.

effect nearly so markedly as the impure alloys is stated by Kellerman to be due to the fact that when the pure metals are used, relatively large particles are detached and the heat of friction is not sufficiently great to set these alight, whereas, when impure alloys are used, smaller particles are knocked off, and the heat of friction heats these more highly than it can larger particles, so that they take fire and burn as they fly through the air.

A few facts about the extent of this new industry may be interesting. In 1911, from 8,000 to 10,000 kg. of these "pyrophoric alloys" were placed on the market, and as from each kilogram of alloy, from 3,000 to 4,000 "firestones" can be made, the number of "firestones" annually produced goes into tens of millions. One of these small "firestones" will give from 2,000 to 6,000 ignitions—and so is equivalent to from 2,000 to 6,000 matches—before being used up.

Their mode of employment is shown in Figs. 1 and 2, which illustrate a simple gas-lighter, Fig. 1 being a bird's-eye view, and Fig. 2 a section. A piece of the pyrophoric alloy is affixed to the end of an arm movable by pressure like the arms of sugar-tongs. When the arm is pressed, the alloy is rubbed right across a file-like iron or steel surface attached at right angles to the end of the other arm, and the slight friction thus caused makes the pyrophoric alloy give out a brilliant shower of blazing sparks, which then ignites any gas in the neighbourhood.

Its use as a cigarette-lighter is shown in Fig. 3. At the top of a small metal box (sometimes shaped like a cigarette, sometimes of larger size) filled with oil and provided with a wick, there is affixed a small piece of pyrophoric alloy, and above this is a steel cog wheel, which can be pressed against the alloy. When the cog wheel is rotated by pressure of a finger, the rotating cogs strike against the pyrophoric alloy just below and detach a shower of brilliant sparks, which then lights the wick. In some forms, the piece of pyrophoric alloy is placed on a box, whose lid is actuated by a powerful spring. When a knob is pressed, the lid flies open and the spring simultaneously sets into rapid motion a steel cog wheel with a rough edge, which, while rotating, strikes off a shower of sparks from the alloy and so automatically lights a wick.

In France, especially, where the match industry is a monopoly in the hands of the Government, and consequently, matches are dear, this new industry has made very considerable headway.

As regards its future development and the ultimate replacement of the ordinary match by such alloys, only a very bold man would care to make a definite prophesy. The invention, in fact, is a highly efficient revival of the old "flint and tinder" method of obtaining fire, which was in use before the advent of the match, and now this long-dead industry appears without warning, to have suddenly flickered up into life again.¹

NOTES ON RECENT THEORY AND PRACTICE.

By HERBERT H. HODGSON, M.A., B.Sc., PH.D.

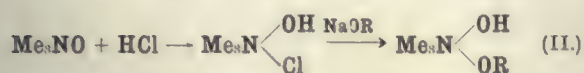
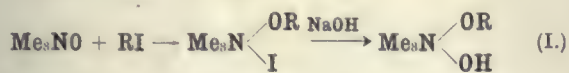
SOME of the most interesting scientific work of recent years has been in connection with the so-called classical researches, especially that undertaken to throw light upon the mechanism of chemical change. Meyer and Beer (*Monatsh.*, 1913, 34, 649—658) have studied the famous Perkin reaction, which, notwithstanding earlier investigations, is still to some extent shrouded in mystery, since it is not certain whether action occurs between the aldehyde and the salt of the fatty acid, or whether the anhydride plays a primary part. These authors now assert that the yield of unsaturated acid depends largely on the aldehyde used: with sodium acetate and acetic anhydride, o-iodobenzaldehyde, o-chlorobenzaldehyde, o-nitrobenzaldehyde, benzaldehyde and p-dimethylaminobenzaldehyde gave yields in decreasing order of magnitude; with potassium acetate and acetic anhydride the relative behaviour of the various aldehydes appears to be the same although the yields are uniformly higher. The latter fact induced an investigation into the nature of the influence exercised by various acetates, o-chlorobenzaldehyde being used; it was found that the alkali metals give better results the higher the atomic weight, and although lead acetate affords similar yields, mercuric acetate is poorer, whilst the acetates of copper and of the alkaline earths produce very small quantities of chlorocinnamic acid. The presence of an acid anhydride is not indispensable, since benzaldehyde heated for 26 hours with potassium acetate and acetic acid gives a 30% yield of cinnamic acid. Michael's view that the Perkin reaction occurs between aldehyde and acid anhydride is found to be untenable from the fact that when o-chlorobenzaldehyde is heated with an acetate and acetic acid, yields of unsaturated acid are obtained, which, in the cases of rubidium and lead acetates, are actually slightly better with the acid than with the anhydride. The rôle of the acetic acid appears to be merely that of solvent, for it was found that a 40% yield of unsaturated acid could be obtained by heating together only o-chlorobenzaldehyde and potassium acetate to 240° C. for 36 hours.

Bodroux (*Compt. Rend.*, 1913, 156, 1079—1081) has studied another classical reaction, viz., the preparation of ethyl acetate, finding that catalytic esterification takes place in dilute solutions. By distilling mixtures of ethyl alcohol and acetic acid with varying amounts of dilute sulphuric acid, the yields of ethyl acetate were found to depend on the quantity of sulphuric acid present, e.g., with 10% H₂SO₄, a yield of 92% was obtained. Numerous other acids were found to exert this catalytic influence, but none were so effective as sulphuric acid.

Meisenheimer (*Annalen*, 1913, 397, 273—300) has presented an interesting paper on the non-equivalence of the five valencies of nitrogen, which he not only assumes, but claims to prove to be the case from

¹ The writer wishes to thank Mr. Wilson, of the British Pyrophoric Alloy Company, Leeds, also the firm Baer & Co., of Berlin, for information regarding these alloys, the blocks being sent by the latter firm.

the existence of amine oxides in enantiomorphous forms. Trimethylamine oxide reacts additively with an alkyl iodide, and its hydrochloride reacts with sodium alkyl oxide as follows:—



The position of the halogen atom in the ammonium salt is occupied by —OH in substance (I.) and by —OR in (II.). Several such pairs of isomerides have been prepared, and in every case the two substances are fundamentally different. The substances, however, have not been isolated in the solid state, but, by the evaporation of their aqueous solutions, I. decomposes quantitatively into trimethylamine, an aldehyde, and water, whereas II. yields trimethylamine oxide and the alcohol R . OH. Pairs of

isomerides of the types $\text{Me}_3\text{N} \begin{array}{l} \text{OR} \\ \text{OR}' \end{array}$ and $\text{Me}_3\text{N} \begin{array}{l} \text{OR}' \\ \text{OR} \end{array}$

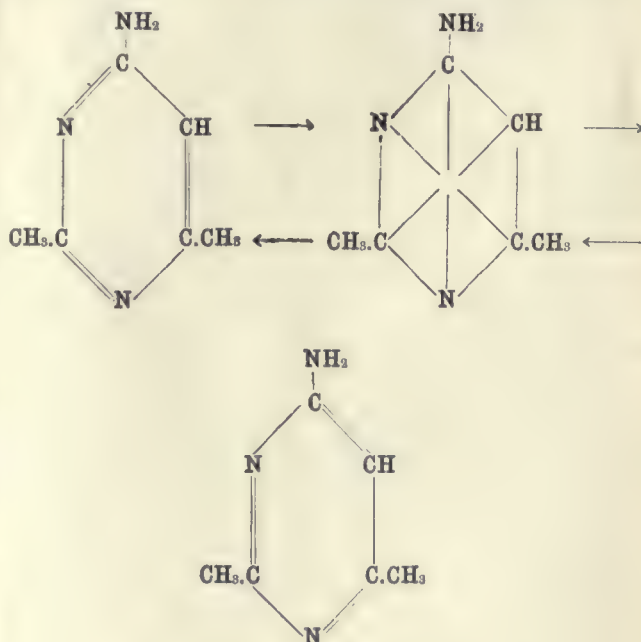
have also been obtained, whose solutions when evaporated yield trimethylamine, an alcohol, and one aldehyde which is always that corresponding to the alkyl group of the alkyloxy-group not attached to the unique "fifth" valency of the quinquivalent nitrogen atom. The two alkyloxy-groups cannot in consequence be attached to the nitrogen atom in the same manner. The author opines that in ammonium compounds the nitrogen is quinquivalent, all 5 atoms or groups being attached to it by principal valencies, 4 in an inner, the fifth in an outer zone unattached to any definite position and therefore exerting no influence on the asymmetry of the molecule. The author represents the behaviour of his isomerides by the formulae:—



Methods for attacking constitutional problems are always valuable, and some experiments by Scheiber and Herold (*Ber.*, 1913, 46, 1105—1110) are of particular interest in this respect. They attempt to determine the constitution of enolic substances by using ozone, with subsequent decomposition of the ozonide formed. The advantages claimed for the method are that the operations can not only be carried out at low temperatures, but that the addition of ozone, as far as is yet known, takes place without previous structural alteration of the substances investigated. A chloroform solution of benzoyl acetone after treatment with ozone was decomposed by warm water, when the cooled solution deposited an almost quantitative amount of benzoic acid, whilst the filtrate, when treated with phenylhydrazine, yielded methyl glyoxalzone. Neither acetic acid nor carbon dioxide could be detected. Benzoyl acetone appears therefore to be enolised according to the formula $\text{OH} \cdot \text{CPh} : \text{CH} \cdot \text{COMe}$, thus confirming Smedley's work. Oxalacetone similarly treated yielded 93.5% of oxalic acid, from which it follows that enolisation must also have

occurred to some extent towards the acetyl group, although acetic acid was not detected.

A study of outstanding importance has been commenced by Morgan and Reilly (*J. C. S.*, May, 1913) on the non-aromatic diazonium salts. They point out that the greatest development in the chemistry of the diazo-compounds has taken place in connection with aromatic amines, owing mainly to two facts: the important technical employment of benzenoid and naphthalenoid diazo-derivatives in the azo-dye manufacture, and the manifold applications of the diazo-reaction to synthetic operations in the aromatic series. Certain non-aromatic amines, however, are known to possess in varying degrees the property of diazotisability, and the authors are starting to investigate within what limits this reaction is manifested by bases which do not contain amino groups attached to aromatic nuclei. The property of diazotisability appears to be connected with the presence in the basic molecule of an unsaturated group, for hitherto it has been impossible to diazotise the salt of any primary base having its amino group attached either to a fully saturated radicle or to a completely hydrogenised ring, *e.g.*, the aliphatic primary amines, bornylamine, and ac-tetrahydro- β -naphthylamine. On the other hand there exist bases with amino groups attached to unsaturated complexes which are not diazotisable, *e.g.*, the authors have not succeeded in diazotising 6-amino 2 : 4-dimethylpyrimidine, a base possessing a six-membered cyclic ring closely akin to that of the benzene nucleus, with the same possibility of ethenoid and centric arrangements of the valencies:



The Badische Company have patented (D.R.—P. 255519) an important method for furnishing satisfactory yields of diolefines, which consists in heating monohalogenated olefines, dihalogenated paraffins, or halogenated alcohols at 300 to 500° C., under ordinary or reduced pressures, with catalytic agents

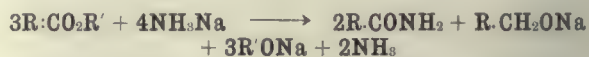
such as barium chloride, nickel chloride, lead chloride, or aluminium hydroxide. The preparation of isoprene by this method from a large number of substances is now recorded, *e.g.*, from β . γ . dibromoisopentane, α . β . dibromoisopentane, etc.

The behaviour of paints in practice has lately been the subject of a piece of work of Baly and Breton, and a trenchant criticism of this has recently emanated from Armstrong and Klein (*Jour. Soc. Chem. Ind.*, 1913, 32, 320—331). The experimental part deals with the formation of volatile products from linseed and other oils, and from the ordinary materials used in paints. The leaf of the common shrub *Aucuba Japonica*, or of the spotted Japanese laurel is used as a test for any lead in the volatile products, since lead blackens these more or less readily. The conclusions arrived at by Armstrong and Klein are, that the vapours produced during the drying of white lead pastes and paints do not contain lead, but consist for the most part of turpentine together with the oxidation products of the oil, which latter are harmless under the conditions of practice. The toxic effects sometimes experienced from drying paints are to be ascribed to turpentine, and in many cases effects which have been regarded as due to lead poisoning are attributable to other causes, especially to turpentine. The dangers attending the use of lead compounds are only the well-known mechanical ones.

While on the subject of lead, an interesting method for estimating small quantities by Elsdon and Stansfield (*J. C. S.*, June, 1913) may be noticed. They confirm Wilkie's statement that lead in the presence of sufficient ferric iron is completely precipitated by ammonia, and use this property as the basis of a convenient method for the separation and estimation of lead in small quantities. Since the lead is concentrated in the ferric hydroxide precipitate it only remains to effect the separation, and to this end the iron was first precipitated in acid solution either as basic acetate or basic formate, but satisfactory results were not attainable by these means. It was found that the more acid the solution the more complete the separation, although eventually a point was reached at which the solution was too acid for complete precipitation of the iron, whilst lead was still carried down. Brearley and Ibbotson's molybdate method was then tried and found applicable for the estimation of minute quantities of lead. In the presence of ferric iron, lead cannot be estimated directly, since free mineral acid interferes with the precipitation, and in weak acetic acid solution iron will be co-precipitated. The authors have found, however, that if the iron be first reduced to the ferrous condition, the lead can be precipitated alone as molybdate in weak acetic acid solution, and this even when the iron is in relatively very much larger quantity than the lead. A single precipitation usually gives too high a result, but by re-dissolving and re-precipitating the lead molybdate satisfactory results are obtained. The influence of tin, antimony and phosphorus on the above procedure was investigated, and these metals were found to be largely, if not completely, carried down

by the iron precipitate, thus necessitating the usual method of dealing with the mixed precipitate to be carried out.

Research in liquid ammonia solution is receiving attention from Chablay (*Comp. Rend.*, 1913, 156, 1020—1022), who has devised a method for reducing esters to primary alcohols by means of sodium and absolute alcohol. The first action of the sodium is as follows:—



Coupling this with the nascent hydrogen from the sodium on the alcohol, the amide is in turn converted into the corresponding primary alcohol, the whole of the ester being thus reduced:—



A large number of the higher fatty acids have been thus converted, while dihydroxy alcohols are obtained from the esters of dibasic acids.

A suggestive paper by Waddell (*Chem. News*, 1913, 107, 206) deals with the behaviour of methyl orange. On the theory of indicators it is strange that methyl orange, a strong acid, should act towards weak acids in exactly the same way as phenolphthalein, a weak acid, acts towards weak bases. This anomaly is removed if methyl orange is regarded as a weak base instead of a strong acid, and the author gives experiments indicating its basic behaviour. According to the ordinary theory, the pink colour is due to the undissociated substance and the yellow to the dissociated ion. All means of diminishing the dissociation, however, tend to change the colour from pink to yellow, *e.g.*, glacial acetic acid gives a red colour which may be lessened, if not destroyed, by the addition of acetates, and is easily changed to yellow by the addition of alcohol.

Colour reactions for detecting minute traces of substances are always valuable, and two recent ones for the detection of thiosulphates and blood are of more than average interest. Pozzo-Escot (*Bull. Soc. Chim.*, 1913 (iv.), 13, 401—402) states that if to 1 or 2 c.c. of the solution to be tested an equal amount of a 10% solution of ammonium molybdate be added, and 5 c.c. of H_2SO_4 poured gradually down the side of the tube to form a separate layer, then a bluish-coloured zone will be formed between the two liquids should a thiosulphate be present. The test will detect 0.0005 gm. of $Na_2S_2O_3$.

Ruttan and Hardisty (*Canadian Med. Assoc. J.*, November, 1912) recommend a 4% solution of tolidine in glacial acetic acid for the detection of small quantities of blood. 1 c.c. of the liquid to be tested is treated with 1 c.c. of 3% hydrogen peroxide, and 1 c.c. of the reagent. If blood be present, a green to bluish-black coloration develops gradually, and persists for several hours. The reagent was found to be capable of detecting 1 part of blood in 7,000,000 parts of aqueous solution, 1 in 24,000 parts of urine, 1 in 100,000 parts of faeces, or 1 in 30,000 parts of stomach contents, and is more sensitive than the similar benzidine reagent.

NOTES ON CHEMICAL ENGINEERING.

By J. W. HINCHLEY, A.R.S.M., Wh.Sc.

CHAPTER IV.

SEPARATION OF SOLIDS BY MAGNETIC METHODS.

THE magnetic properties of different materials may determine a convenient method for their separation, but the use of this property for the separation of feebly magnetic material has only become important during the last few years, although the removal of pieces of iron, nails, etc., from raw materials by magnetic separators constitutes the first operation in many industries.

In magnetic separators a stream of material is

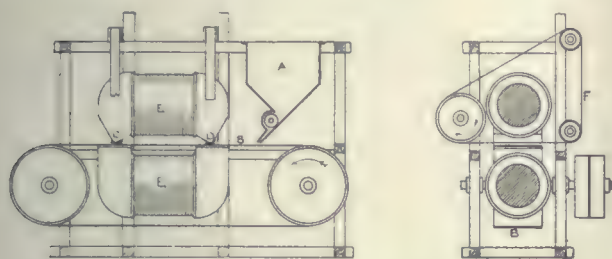


FIG. 42.—"WETHERILL" SEPARATOR.

brought under the influence of movable or stationary magnetic fields, which either hold, withdraw, or deflect the magnetic material from the main stream. For simplicity, there may be said to be two classes of machines: (1) lifting machines, in which the magnetic material is bodily raised out of the moving stream; (2) deflecting machines, in which the magnetic particles are deflected in a falling stream. Each of these classes may be subdivided into types and modified for working in water. The simplest type of the first class of machine consists in suspending permanent or electro-magnets over the stream of material carried on a conveyor or in a shoot. The attendant, who removes the material as it accumulates, is usually employed at the same time in removing by hand any other defective material that may be present. Such a crude plant is only justified in rough operations or where careful examination or picking takes place.

When close magnetic separation of feebly magnetic material is required, the material must be reduced to a uniform size dependent on its character and the closeness of the separation. A good type of lifting machine is shown in Fig. 42, a variety of the "Wetherill" separators. The material is placed in the hopper A and fed in a uniform layer to a depth depending on the character of the material and the separation required, on to the travelling belt B. At the points C and D magnetic fields are produced by means of the electro-magnets E. The upper pole piece is made in the form of a wedge while the lower pole piece is a flat surface, so that the magnetic potential is enormously increased in the neighbour-

hood of the upper pole, and very feebly magnetic particles are readily lifted from the bed. The lifted material is usually removed by another travelling belt moving in contact with the upper pole so that it receives the magnetic particles on its lower surface. These belts are generally placed at right angles to the feeding belts, but other positions are common. The edge of the upper pole piece is generally inclined to the feeding belt at the angle of the resultant velocity of the feeding and taking-off belts. The speeds of these belts are always determined by trial and vary from 100 ft. per minute for feebly magnetic material to 1,000 ft. per minute where separation is easy. The distance apart of the belt surfaces varies in practice from $\frac{1}{2}$ in. to $1\frac{1}{2}$ ins., the width of the feed belt being 18 ins. and that of the taking-off belts 3 ins. Bronze shoes are fitted on the pole pieces to take the wear of the belts, and in the case of strongly magnetic material the lower shoe is made very thick or the pole itself is increased in area to facilitate the lifting action of the field.

A modification of this machine, in which the taking-off belt travels in the same direction as the feeding belt, is shown in Fig. 43 and is more suitable for strongly magnetic material. A series of magnets with their poles alternating are placed above the belt, and by the consequent agitation of the attracted particles prevent entanglement with them of non-magnetic material. The energy required for such machines varies from 1 kw. for easy work to 10 kw. for difficult work, and the rate of working may vary from 1 to 15 tons per hour according to the speed of the belts and the depth of the bed.

The most important class of machines are those which act by deflecting the magnetic material. In the magnetic drum (Fig. 44), which is most commonly used for separating nails, etc., from raw materials, internal magnets are provided to produce a series of magnetic fields at its surface. The material is fed

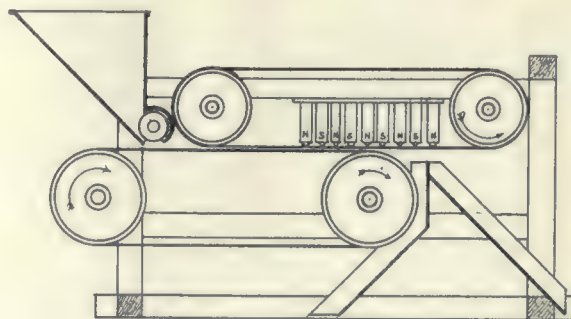


FIG. 43.—BALL-NORTON SEPARATOR.

into the hopper A and shaken down the shoot D which is agitated by the cam shaft B. A small pulley on B drives a larger pulley on the magnetic drum shaft at C. The non-magnetic material falls

on the shoot F, while the magnetic material is carried under the machine and falls on the shoot G. The magnetic fields on the surface of the drum generally terminate at the lowest point of the drum, and in some cases a mechanical method of cleaning the drum is provided just beyond this point.

An ordinary belt conveyor is often modified by providing a magnetic drum for carrying the belt at the

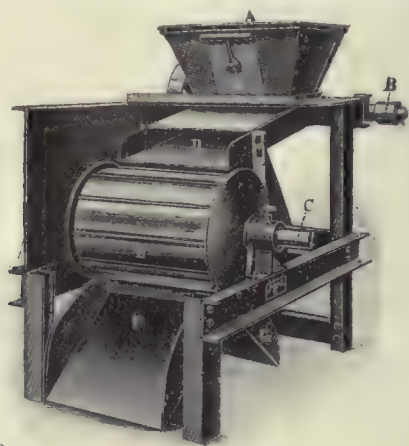


FIG. 44.—MAGNETIC DRUM.

delivery terminal, with suitable shoots for receiving the separated materials. This arrangement is valuable on account of the saving in head-room and also in cost.

By providing a series of drums and running them at different speeds the material may be subdivided into several grades according to their magnetic qualities. In the "Monarch" separator (Fig. 45) the magnetic drum A performs a first separation, and the separated material is again treated by the second drum B. By running B at a higher speed, or by using weaker magnetic fields, a portion of this material falls into D while the highly magnetic particles are discharged at E.

In other types of machine a magnetic field is formed at the surface of the drum by an external

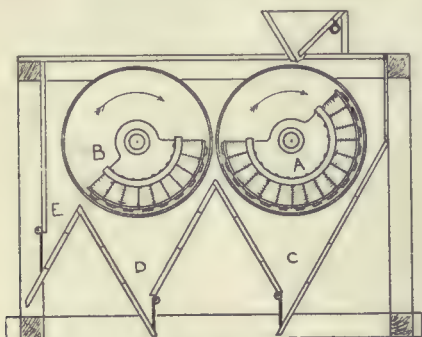


FIG. 45.—"MONARCH" SEPARATOR.

magnet. In the "International" separator (Fig. 46), the drum consists of a series of laminated iron discs whose edges are formed into teeth, to give a more concentrated field at definite and regularly arranged points on the drum surface. The drum is rotated at

a superficial speed of 300 ft. per minute, and the material is carried by it into the air space of the magnet, contact with the pole being prevented by a brass liner. The magnetic field is strongest at *b* and becomes weaker until at *a* a neutral point is reached. The non-magnetic material falls from the point *b*, while the magnetic material is deflected and falls into the shoots C and D. By careful adjustment of the shoots strongly magnetic material can

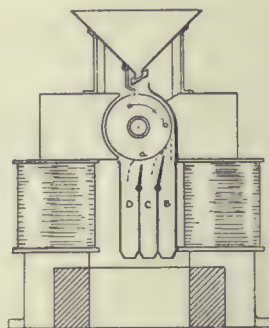


FIG. 46.—"INTERNATIONAL" SEPARATOR.

be separated from feebly magnetic material and also from non-magnetic or dia-magnetic material with commercial success, but as a rule two treatments of each product are necessary. In another type of machine the rotating drum is omitted and a travelling band running over the polished end of the pointed pole piece carries the material to the magnetic field; deflection of the magnetic particles takes place as the material falls.

The treatment of sands and other finely divided material for the separation of particles of the same specific gravity but of different magnetic permeability is daily accomplished by the use of these machines.

For the preliminary treatment of bones, phosphates, copra, etc., the cheapest and most efficient device is shown in Fig. 47.

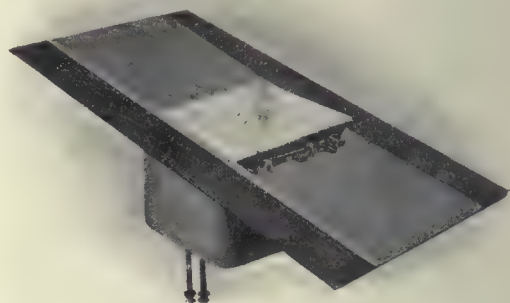


FIG. 47.—MAGNETIC SHOOT.

The shoot is inclined at an angle of about 45 degs., and as the material passes down it any iron fragments are deflected and held by the magnet poles out of the way of the main stream. At intervals, of course, the accumulated iron must be removed by stopping the feed and switching off the current.

Separation of Solids by Electro-static Methods.—

A method of separation has been developed during recent years depending on differing electrical conductivities of the particles. When a stream of material is brought into contact with an electrically charged body, the good conducting particles become similarly charged and repelled at once, while those which are bad conductors continue for some time to be attracted. If in addition all the material be charged with electricity of opposite sign before being brought into contact with the charged body a more definite separation of particles takes place.

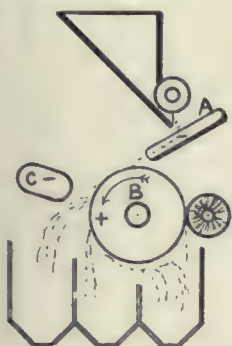


FIG. 48.—ELECTRO-STATIC SEPARATOR.

The principle of such machines is illustrated by Fig. 48. The material sliding down the shoot A becomes charged, and falling on the rotating metal roller B, which is charged to an opposite sign, is separated into streams according to the conductivities of the individual particles. An electrode C charged to the same sign as the shoot intensifies the electrical field and improves the separation.

The electrical charges were at first supplied by induction machines, but these were only satisfactory in good weather and with the best supervision. An alternating current of high potential is now rectified for the same purpose. Variations in size of the material must be avoided and the separation is much affected by uneven dryness. With careful reduction and sizing the method is becoming most useful for concentrating graphite, molybdenite, blende and sulphides generally.

(To be continued.)

Aluminium Corroded by Mercury.—An interesting report of an accident caused by a corroded aluminium vessel in a brewery is related in the *Tageszeitung fuer Brauerei*, of Berlin. In consequence of the breaking of a thermometer, the quicksilver came in contact with an aluminium vessel, and within a few hours holes were eaten into the tank. Where aluminium vessels are used, thermometers should be filled with alcohol.

Discovery of "Kieselguhr" Deposits.—It is reported that an important discovery of "kieselguhr" or infusorial earth, has been made on the island of Chiloé. A Chilean company was formed some time ago to buy up what was supposed to be large chalk deposits in the island, but the mining experts who went there found the substance to be "kieselguhr." An expert who surveyed the deposits reports that one deposit was found to contain over 86% of almost pure kieselguhr, and that the other deposits contain from 78 to 85%, but are not so free from iron and alumina.—*Board of Trade Journal*.

PERSONAL AND OTHER NOTES.

PROFESSOR H. C. H. CARPENTER, professor of metallurgy in the Victoria University of Manchester, has been appointed to the chair of metallurgy in the Royal School of Mines, South Kensington.

Professor W. A. Bone, F.R.S., has been awarded by the Franklin Institute of Philadelphia the Howard N. Potts gold medal in recognition of his work on surface combustion, on which subject he gave a lecture before the institute in October, 1911.

Professor S. M. Dixon, professor of civil engineering in the University of Birmingham, has been appointed to the new chair in civil engineering in the City and Guilds (Engineering) College.

The resignation of Mr. Roberts Beaumont from the professorship of textile industries at the Leeds University has been accepted by the Council.

Dr. Rash Behary Ghose has given £66,666 to the Calcutta University College of Science to be devoted to the foundation of professorships and studentships.

The first report of the General Board of Studies of the University of Cambridge reports that much work has been done in connection with the provision and fitting up of new appliances and costly pieces of apparatus for the laboratory. The number of students who attended courses of lectures as judged by class entries was 575 for the Lent Term, 1913, as compared with 464 for the Easter Term, 1912. A donation of £100 by the Jacksonian Professor towards the laboratory funds, payable annually for the last five years, has materially assisted in the development of the resources of the laboratory. The number of papers descriptive of original work done in the laboratory as published during the last twelve months is a very important one, the actual number of papers being 40. These have been contributed by W. J. Pope, H. O. Jones, S. Ruhemann, W. J. Sell, J. E. Purvis, C. T. Heycock, A. J. Berry, and others. The list of papers and the variety of the subject-matter illustrates the continuation of that activity which has characterised the Cambridge Laboratory of recent years. The professor reports that students both of chemistry and engineering are making more extended use of the facilities afforded by the Metallurgical Laboratory.

Nature states that the Institut International de Physique Solvay has a sum of 20,000 francs available for the encouragement of experimental work in physics and physical chemistry, particularly for investigations on radiation phenomena, and the theory of energy quanta and of molecular theories. Grants from the fund will be awarded without distinction of nationality by the administrative commission of the institute on the recommendation of the international scientific committee. The administrative commission is composed of Profs. P. Heger, E. Tassel, and J. E. Verschaffelt, Brussels; and the scientific committee of M. H. A. Lorentz, president, Haarlem; Mme. M. Curie, Paris; M. Brillouin, Paris; R. B. Goldschmidt, Brussels; H. Kamerlingh-Onnes, Leyden; W. Nernst, Berlin; E. Rutherford, Manchester; E. Warburg, Berlin; and M. Knudsen, secretary, Copenhagen. Applications for grants should be made before September 15th to Prof. H. A. Lorentz, Zijlweg 76, Haarlem, Holland.

ENGINEERING NOTES.

By R. J. DUNDERDALE, B.A. (CAMB.), A.M.I.C.E.

Road Board Congress.

At the meeting of the International Road Congress held on June 24th the chief interest was centred in the summary of Mr. J. Walker, the "general reporter" of the section, on Bituminous-bound Macadam.

In this country the interest of this section for the gas manufacturer and tar distiller should be very great, for we may assume that much more of the products of the gasworks finds its way into our roads than of the lake in Trinidad.

At first sight some of the conclusions appear to be a little vague, and even purposely so—but when the enormous variety of subsoil and foundation conditions are taken into account, it will be found that the surprising thing really is the closeness in general agreement as to treatment in the case of bituminous-bound macadam.

With regard to the "particular conclusions" in the report, the first on "Foundations and Drainage" must present the most important point and the greatest difficulty in many places.

Not to go outside this country, the Essex mud flats and the neighbourhood of Hull (where the foundations of some of the churches rest on wooden rafts) must present a considerable problem.

The second point was the size of macadam, and on this, agreement as to size and cubical shape seemed fairly pronounced. Those speaking in the discussion following said that for Victorian roads brick tiles a foot square were found serviceable. In this case, it seems fair to assume that traffic is light and tar not used as a binding.

In section 6, the points, though in some cases somewhat obvious, are well advised: (a) that dry stone be used with the binder; (b) that the crust must be laid on a dry foundation in fine weather (rather a steep condition in this country); (c) too much binder is a disadvantage; and (d) too heavy road-rollers are to be avoided.

(a) and (b) cannot always be easily obtained in this country, (c) is very sound whatever binder for whatever purpose be used, and amounts to a general proposition on binders for any and every purpose as well as for roads.

Section 7 is probably the most important section of the lot, apart from its interest to chemists (tests and chemical analysis), a quantity of gasworks tar (not pitch), is probably supplied pretty wet—as tar, except after very prolonged settling, usually holds a good deal of liquor.

Section 9 states that owing to the easier cleaning of tar macadamed streets, considerable hygienic advantage should be obtained—it would be interesting to know in view of the recent inquiry on "pitch cancer" and allied points, if tar macadam may not actually be producing a new danger. In the discussion following all the foreign delegates emphasised the dustlessness of the more important English roads. It is kind of them, but it is to be hoped that it is not the last word.

Wet Coal Storage.

Some remarks on coal storage in general were made in this column in the April number for this year.

The Hammersmith Borough Council have now

authorised a scheme for the hydraulic handling and wet storage of a large tonnage of coal, with a view to mitigating the danger to their electric power supply should anything in the nature of another coal or railway strike occur.

A pipe line about 600 yds. long is to be laid from the wharf to the power station wet storage tanks, and the coal, after weighing, will be hydraulically delivered through the pipe line to the tanks.

The amount of coal to be delivered to the pipe line will be about 15% of the total volume of water and coal going through, and the speed of the mixture will be about 7 ft. per sec., i.e., about as fast as one can conveniently walk. If there are any bends at all in the body of the pipe, this speed will probably be found a trifle slow, for it is astonishing with what facility a gritty substance like coal or small stones will contrive to build up a block in a pipe line in the face of all reasonable probability. The scheme has, however, doubtless been fully worked out, and probably no trouble is to be feared when in six months' time the plant should be completed. It is estimated that the cost of delivery through the pipe should be less than 1d. per ton, as opposed to 7d. by the present method, and if this is so, this saving alone should bulk very handsomely against the interest on the expenditure on the device, as this is reckoned at about £10,000.

Marine Gas Producer Plant.

A short article appeared in the *Times Engineering Supplement* for July 30th, on the *Archer*, a boat built for and used by the Tacoma and Roche Harbour Oil Co., between Roche Harbour in the State of Washington and San Francisco. The boat is 900 tons gross, and the producer of 300 H.P., so that though not large, the boat is more than a toy or a demonstration in miniature.

Her speed is not given, but is presumably about 9 knots. The interesting thing about the boat both from an engineering and chemical standpoint, is that the producer burns a cheap grade of lignite with a high moisture and ash content, and what is more to our purpose, a high tar content.

This tar is entirely removed from the gas before entering the valves of the engine by centrifugal washers, and herein—if the boat is as successful as stated—appears to be the chief cause of congratulation. At one time the sea-going gas engine was greatly hampered by the difficulty of reversing, but when Alston and others had satisfactorily overcome this, a really far more serious matter presented itself—the probability that the producers would have to consume anthracite for fear of tar troubles at the valve and deposits of carbon from the same source in the cylinders.

Now, commercially speaking, a boat is rather hopeless which can only run on the best hard anthracite, for such a commodity, apart from its expense at the cheapest points, is absolutely unobtainable in a great many parts of the world.

This, in fact, appeared to the writer to be the chief drawback to an admirably-engined producer gas-boat, which he was asked to inspect for a gentleman on whose capital the promoters of the engine desired to draw.

The engine and producer were very cleverly designed, but at the time no serious attempt had been made on the scrubbing problem, and the boat burned anthracite. The article referred to, by the way, stated that the lignite was cheap, but as its mean price was \$2.25, and water and ash content together amounted to 40%, its price on a dry and ashless basis would be over 15s. a ton—this is an indication of the probable price of anthracite in the locality.

REVIEWS OF BOOKS.

"THE MINERALOGY OF THE RARER METALS." By E. Cahen and W. O. Wootton. CHARLES GRIFFIN & Co., LTD., London, 1912. Pages 211 + xiv, including Index. Price 6/- net.

THE list of minerals dealt with in this work may be considered complete up to March, 1912. The authors follow Dana's well-known classification. In order that the data may be correct in detail many chapters have been revised by specialists in their particular line. This work cannot fail to be of value to prospectors, who, as the authors say, have often walked over ores in the past and failed to recognise those of the rarer metals. An approximate account of the uses to which such metals may be placed, and also their market value, is given.

The work gives evidence of great care having been taken in its compilation. The final section dealing with geographical distribution is particularly useful; also the particulars given for the assay of the rarer metals.

"ORGANIC CHEMISTRY; Including Certain Portions of Physical Chemistry." By Howard D. Haskins. CHAPMAN & HALL, LTD., London, 1913. Pages 430 + xiii, including Appendix and Index. Chapters XXXII., with 25 Illustrations. Price 8/6 net.

This text-book has reached a second edition, and is written chiefly for the use of medical, pharmaceutical, and biological students in the Western Reserve University.

The work is divided into thirty-two chapters, and is well arranged for the guidance of those students for whom it is intended. An appendix gives certain tables of general interest. The book may certainly be recommended for the consideration of teachers in chemistry, and may obtain a vogue in this country.

"METHODS OF ORGANIC ANALYSIS." By Henry C. Sherman. THE MACMILLAN COMPANY, New York, 1912. Second Edition. Rewritten and Enlarged. Pages 407 + vi, including Index. Chapters XVIII., with 17 Illustrations. Price 10/6 net.

This work, which deals with the analysis of alcohol, aldehydes, carbohydrates, vinegar, oils, soap, grain products, etc., and the detection of food preservatives, is a useful one for the student, and the fact that it has passed into a second edition is evidence that this fact has been realised. A useful addition at the end of each chapter is a series of references to some of the chief works and papers on the subjects dealt with in the same.

"ELEMENTARY CHEMICAL THEORY AND CALCULATIONS." By Joseph Knox. GURNEY & JACKSON, London, 1912. Pages 100 + iv, including Index and List of International Atomic Weights. Chapters XII. 2/- net.

This work is divided into twelve chapters, and deals with calculations, influence of pressure of

gases, laws of chemical combination, determination of molecular weights, diffusion of gases, atomic weights, and percentage composition, etc. Many interesting examples are given, and also problems for solution by the student, with answers to the same.

"MANUFACTURE OF NITRO-LIGNIN AND SPORTING POWDER." By Earle Durnford. WHITTAKER & Co., London, 1912. Pages 84. Price 5/- net.

This work gives particulars of the manufacture of nitro-lignin as a base for sporting powder. It is claimed that the nitro-lignin powders give easier pressures than those made with cotton, and give less dust in the process of manufacture. On a question of yield nitro-lignin does not compare quite so favourably with gun-cotton.

The author has evidently had considerable experience in the manufacture of powder from this material, and this book will be found a useful one for those interested in the manufacture of explosives.

BOOKS, ETC., RECEIVED.

"Organic Chemistry for Advanced Students," Vol. II., by Julius B. Cohen. Edward Arnold, London, 1913. Pages 427 + vii, including Index. Chapters V. Price 16/- net.

"Production et Consommation des Engrais Chimiques dans le Monde." Published by the Institut International d'Agriculture, Rome, 1913. Pages 134, with 4 Curves and 1 Map. Price 3 francs.

"Die Kultur der Gegenwart," Vol. III. *Chemie*, edited by von E. v. Meyer; *Allgemeine Kristallographie und Mineralogie*, edited by von Fr. Rinne. Assisted by C. Engler und L. Wohler; O. Wallach; R. Luther; W. Nernst; M. Le Blanc; A. Kossel; O. Kellner und H. Immendorf; and O. Witt. Teubner, Leipzig, 1913. Pages 663 + xiv, with Index and 53 Illustrations. Price M. 18.

"Merck's Reagenzien Verzeichnis." E. Merck, London, 1913. Third edition. Pages 446. Price 6/6.

"A Treatise on Quantitative Inorganic Analysis," Vol. I., by J. W. Mellor. Charles Griffin & Co., Ltd., London, 1913. Pages 778 + xxxi, with Appendix and Index. Divided into V. Parts and XLIV. Chapters, with 2 Coloured Plates and 206 Illustrations. Price 30/- net.

"Bulletin of the Imperial Institute," Vol. XI., April—June, 1913, edited by the Director and Staff, and by other contributors. John Murray, London, 1913. Pages 186, with Illustrations and Tables. Price 2/6 net.

"Colloids and Their Viscosity." A General Discussion. Reprinted from the "Transactions of the Faraday Society," 1913. Pages 75, with many Illustrations and Curves. Price 7/6.

"Forty-Ninth Annual Report on Alkali, etc., Works," by the Chief Inspector. Proceedings during 1912. Published by His Majesty's Stationery Office, London, 1912. Pages 131, including 3 Illustrations. Price 8½d.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.

7457/12. OBSTCHESTVO PROIZVODSTVA and TORGVL I RESINOVYMI IZDELIAMI "BOGATYR" and I. OSTROMI-SLENSKY. **Improved Manufacture of Rubber or Rubber-like Substances from Halogen Compounds with Organic Substances.**

8323/12. I. McDUGALL, S. McDUGALL and F. HOWLES. **Manufacture of Tar Acids.**

In the manufacture or recovery of tar acids from tar distillates, a mixture of alcohol and water is used as an extracting agent for mechanically separating the said acids from the distillate.

11470/12. S. C. DAVIDSON. **Indiarubber.**

In the extraction or coagulation of indiarubber from latex, a dilute alkaline aqueous solution of creosote or carbolic acid, or both, and with or without formaldehyde, is added to the latex as a first treatment thereof and prior to coagulation of the rubber therefrom.

11828/12. C. TORLEY and O. MATTER. **Manufacture of Nitrous Oxide.**

A process for the manufacture of nitrous oxide consists in introducing ammonium nitrate as a solution or as a solid body continuously into a reaction vessel which contains a filling material that is heated to or above the decomposition temperature of ammonium nitrate, and maintaining the reaction mass in motion during the process by means of a stirring apparatus.

12242/12. A. MESSERSCHMITT. **Process and Apparatus for the Production of Hydrogen.**

12243/12. A. MESSERSCHMITT. **Apparatus for the Production of Hydrogen.**

14273/12. G. A. CHAPMAN, S. TUCKER and MINERALS SEPARATION, LIMITED. **Ore Concentration.**

14456/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & CO. **Manufacture and Production of Caoutchouc Substances.**

14585/12. CENTRALSTELLE FÜR WISSENSCHAFTLICH-TECHNISCHE UNTERSUCHUNGEN, G.m.b.H. **Ammonia.**

In the production of ammonia from its constituent elements, ruthenium or compounds thereof is used as a catalyser.

14586/12. RHEINISCHE DYNAMITFABRIK. **Nitroglycerine.**

In the production of nitroglycerine from a mixture of glycerine and acids, hydrofluoric acid or salts thereof, together with silica or readily decomposable silicates, are employed to produce an evolution of gaseous bubbles of silicon tetrafluoride in the mixture of nitroglycerine and acids.

14637/12. A. BINARD. **Furnaces and Apparatus for Roasting Ores.**

14652/12. J. SMITH, H. L. MITCHELL, W. H. ASKHAM and H. HEY. **Absorber for Gases or Vapours.**

In an absorber or separator for gases or vapours provided with corrugated plates over or through which the gases or vapours pass, and over which the absorbent liquor

also flows, the corrugated plates are so arranged that the depressions of one plate correspond with and enter somewhat into the depressions in the plate below to form a number of liquid seals or traps through which the gases or vapours must pass in the operation of the device.

14896/12. MASCHINENBAU-ANSTALT-HUMBOLDT. **Briquetting.**

The process for consolidating ore briquettes, and more particularly briquettes of iron ore, consists in charging the briquettes into a tunnel kiln with interstices between them, the interstices being filled with fuel and the briquettes burned by air which is blown through under pressure.

15460/12. A. L. J. QUENEAU. **Improved Method and Apparatus for Roasting Zinc Blende.**

15546/12. MINERALS SEPARATION, LIMITED. **Apparatus for Ore Concentration.**

15965/12. W. KAEMPFE. **Waterproof Fabrics.**

In the manufacture of American cloth and the like waterproof fabrics and substitutes for leather and waxed fabrics, there is substituted a material or oil produced by treating an animal oil or a fish oil with superheated steam for the drying oil or oils employed hitherto for the said manufacture.

15977/12. K. BURKHEISER. **Ammonia.**

For increasing the yield of ammonia from gases of distillation, the cyanogen of the gases is converted by any suitable known process into sulpho-cyanide, and then this sulpho-cyanide is converted by any suitable known process into ammonia; the ammonia thus obtained is then further worked up with or led into the ammonia already contained in the gases.

17014/12. F. O. BYNOE and H. EDWARDS. **Tempering Steel.**

Steel is tempered by the application of superheated steam of low pressure and high temperature exhausting into the atmosphere or into a condenser.

17502/12. F. KNÜTTEL and THE BERLINER ACTIEN-GESELLSCHAFT FÜR EISENGIESSEREI UND MASCHINEN-FABRIKATION. **Malting Drums.**

A malting drum rotatably mounted with its circumference on rollers and having, for the purpose of aerating the malt, a perforated central tube and stationary supply and discharge pipes, has, according to this invention, valve discs arranged on the central lateral openings of the drum for the purpose of periodically completely closing the interior of the drum against admission of air, the seats and closing discs of the valves rotating with the drum during the rotation of the latter, so that an air-tight closing of the interior of the drum against admission from the stationary air pipes is ensured even during axial and radial movements of the drum.

1384/13. THE MANCHESTER PAINT AND VARNISH CO., LIMITED, and T. W. JORDAN. **Purification of Coal and other Gas.**

17072/12. A. W. GREGORY. **Method of Treatment of Solutions Containing Metallic Salts for the Removal of Iron.**

17756/12. J. H. BARKER and BIRMINGHAM METAL AND MUNITIONS CO., LIMITED. **Annealing and like Heat Treatments of Metal Bodies.**

17904/12. R. E. CHICHESTER. **Malt.**

In apparatus for treating grain in the production of malt in revolving drums, air or other elastic fluid is caused to flow across the surface of the bulk of the grain, which bulk, owing to the rotation of the drum, has a stream of grain continuously gravitating over its surface.

18310/12. A. DE KADT. **Fatty Acids and their Esters.**

In the manufacture of saturated compounds from unsaturated fatty acids or their esters by subjecting the fatty acid or ester to the action of hydrogen in the presence of a catalyser, the catalyser is a soap of a heavy metal or of a noble metal made from a fat or fatty acid having a melting point higher than that of the saturated compound to be produced.

18053/12. BADISCHE ANILIN UND SODA FABRIK. **Manufacture of Isopentenes and Homologues thereof.**

19409/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & CO. **Manufacture and Production of Cyclic Ketones.**

The process for producing cyclic ketones consists in submitting to distillation adipic acid or its higher homologues or the substitution products of these acids.

19600/12. M. PLATSCH. **Sulphite Cellulose.**

For purifying lyes from the manufacture of sulphite cellulose, the lye is first concentrated until the acids of the acetic series are substantially removed, and then the impurities are precipitated.

20061/12. E. UTESCHER. **An Improved Process for Saturating Unsaturated Fatty Acids and their Glycerides by Combining them with Hydrogen.**

22078/12. A. G. FRENCH. **Production of Manganese Sulphate.**

22436/12. CHEMISCHE FABRIK VON HEYDEN, AKTIENGESELLSCHAFT. **Viscose.**

A process for the manufacture of artificial threads from viscose consists in spinning viscose into aqueous solutions of strong mineral acids in such a manner that in a first phase a water soluble thread is obtained which after having been spooled up is transformed in a second phase into a thread insoluble in water.

THE IMPORTANCE OF VISCOSITY FOR THE STUDY OF THE COLLOIDAL STATE.

By WOLFGANG OSTWALD (Leipzig).

(Continued from p. 267.)

NOWADAYS, indeed, these transition phenomena occupy the first place in the attention of the colloidal chemist. He determines the dependence of all possible properties and processes on the degree of dispersity, and finds the most interesting transitions towards the behaviour of molecular dispersoids of analogous composition; the work of The Svedberg may be quoted as an instance. Viscosity has been studied remarkably little in this connection. A number of such transitional systems on the border of colloidal and

molecular dispersity may, however, be mentioned, which show pronounced *anomalies of viscosity*, peculiarities which in many ways recall those of colloids.

Such systems are, first of all, the *critical mixtures of liquids*, e.g., butyric acid-water at certain temperatures and concentrations. J. Friedländer,¹³ V. Rothmund¹⁴ and others have shown that an *enormous rise* of viscosity takes place in such mixtures on cooling *before* the separation into a macro-heterogeneous system. While, for instance, at a certain temperature, the viscosities of water and isobutyric acid are 1.12 and 1.48 respectively, the viscosity of the critical mixture at the same (or indeed a slightly higher) temperature amounts to 3.68. The anomaly becomes even more marked if the *temperature co-efficients* are considered, i.e., the percentage increase in viscosity per degree (or the logarithms of the times of transpiration). Thus the percentage increase in the viscosity of a critical water-isobutyric acid mixture with 38.6% of acid at 0.15 from the point of saturation amounts to 34.3% *per degree*. This enormous increase obviously recalls the behaviour of gelatinising colloids. If we bear in mind that both the gelatinising of colloids and the increased viscosity of critical mixtures are accompanied by increased opalescence, etc., the analogies often referred to between critical separation and gelatinisation become still more marked.

Other systems with entirely analogous anomalies of viscosity are, for instance, *liquid sulphur* above 130° and the opalescent fused *crystalline liquids*. Here, too, we meet with enormous temperature coefficients of viscosity, accompanied by optical and other phenomena which vividly recall analogies with colloids. On cooling molten sulphur from about 400° to about 200° the viscosity rises from 150 to about 50,000, to fall again to 8 at about 150°. The viscosity of molten sulphur also depends on the previous thermal treatment, and the general temperature-viscosity curves are, as regards shape, almost identical for critical mixtures, crystalline liquids, and fused sulphur.

A certain similarity with the curves of albumin coagulation and of the gelatinisation of starch can also be hardly overlooked.

It is hard to believe that this extremely far-reaching agreement of the curves should be only external. On the contrary, general colloidal chemistry here appears to be called upon to settle finally controversies of long standing, such as the question: are crystalline liquids or critical mixtures *homogeneous* or *heterogeneous*?¹⁵ This same question has for years been the central point in the discussion of *colloidal* systems. Modern colloidal chemistry here replies, that normal colloids, critical mixtures, crystalline liquids, molten sulphur, etc., are all *disperse* systems, i.e., systems whose properties are periodically discontinuous in space, this period being extraordinarily small. This, of course, applies equally to molecular systems and to coarsely heterogeneous ones, and the definition is thus much more general than any definition based on the theory of phases. The more special questions arise only in the second place, such as the questions of the degree of dispersity, the solid or liquid state, the formation of solvates, etc., of the disperse portion, in brief, the kind and number of properties which still show periodical discontinuities in the system under consideration. It is purely a matter of definition which

¹³ J. Friedländer, *Zeitschr. phys. Chemie*, 38, 404 (1901).

¹⁴ V. Rothmund, *ibid.*, 63, 54 (1908).

¹⁵ L. Rotinjan, *Zeitschr. phys. Chemie*, 62, 609 (1908).

¹⁶ See W. Ostwald, *Koll. Beih.*, 4, 1 (1912); as regards crystalline liquids also *Koll.-Zeitschr.*, 8, 269 (1911).

discontinuities are to be considered as characteristic for a system of several phases, if a disperse system is to be described as such, and thus the contrast homogeneous-heterogeneous has no longer any justification in fact for such systems. This dispute has, indeed, one may say, almost imperceptibly disappeared from the discussion. The agreement here demonstrated between the anomalies of viscosity in systems apparently totally different from one another surely justifies us in considering such systems together experimentally from the point of view of the theory of disperse systems.

In conclusion, I should ask to be permitted to make a few remarks on the importance of viscosity measurements in the field of applied colloidal chemistry, and in regard to both scientific and practical applications. Of the former must be mentioned the viscosimetric examination of blood and of the body fluids generally, both in the normal and the pathological state. A literature of several hundred papers, devoted to this one application of the viscosity of colloids, is already in existence. Nor is there any doubt that many further investigations in this field are required, to ascertain which of the very numerous variations observed so far may be used, e.g., for diagnostic purposes. It is not surprising that the results obtained so far in these researches appear somewhat complicated. Even the exact viscometric study of simpler colloids is in many ways still at the first stage of its work, that of elucidating phenomena, so that even here it is rarely possible to speak of quantitative comparisons.

A particularly interesting technical application of viscosity determinations we find in the chemistry of india-rubber. A large number of investigators (S. Axelrod, P. Schidrowitz, C. Beadle and H. P. Stevens, H. Fol, and others, see particularly the last issues of the *Koll.-Zeitschrift*) have pointed out that the viscosity of rubber sols may give a clue to the physical properties of the undissolved rubber. Thus, in general, the "nerve" of rubber corresponds to a higher viscosity of its solution; "killed," i.e., depolymerised rubber which has been rendered less elastic, gives lower viscosities at the same concentrations than rubber not thus treated mechanically, etc. It has sometimes been stated that the viscosities of rubber sols depend on so many factors that their practical application appears impossible. The problem may have a large, but certainly not a practically infinite, number of variables and a systematic study may take much time, but is certainly neither impossible nor as uninteresting or unimportant as it may perhaps appear to some rubber experts. It must, of course, be admitted that such a practically exhaustive and systematic investigation of the viscosity of even an ordinary aqueous emulsoid has never yet been carried out. Such a monographic investigation of some selected colloid would certainly be of the highest value as a standard example of the technical application of viscometry.

Many further applications besides those quoted may be mentioned. Such are the analytical use of viscosity measurements in estimating the value of glue, starch, and adhesives, the viscometric examination of oil, lubricants, and similar complex systems, etc.

The official founder of colloidal chemistry, Thomas Graham, has himself drawn attention to this point. As you know, this many-sided investigator is one of the first authors who carried out any viscosity—or, as they were then called, "transpiration"—measurements. It is, therefore, intelligible that Graham should have noticed the peculiar variability of just this property in colloidal systems, and should have emphasised its importance. In this sense

he said "that a liquid transpiration tube may be employed as a colloidoscope." This surely expresses an unusual appreciation of the importance of viscosity measurements, on the part of the founder of colloidal chemistry.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

EIGHTY-THIRD Annual Meeting. Birmingham, September 10th—17th, 1913.

SECTION B.—CHEMISTRY.

President.—Professor W. P. WYNNE, D.Sc., F.R.S.

Vice-Presidents.—Professor ADRIAN BROWN, M.Sc., F.R.S.; Professor P. FRANKLAND, Ph.D., M.Sc., F.R.S.; Professor A. SENIER, M.D., Ph.D.

Secretaries.—E. F. ARMSTRONG, D.Sc., Ph.D. (*Recorder*); C. H. DESCH, D.Sc., Ph.D.; A. HOLT, D.Sc.; HAMILTON McCOMBIE, M.A., B.Sc., Ph.D.

Presidential Address by Professor W. P. WYNNE.

Joint Discussion with Sections I and M on Fermentation.

(a) *Discussion* on Optical Activity, opened by Dr. R. H. PICKARD. *Speakers*:—Professor FRANKLAND, Professor ARMSTRONG, Dr. T. S. PATTERSON, Dr. A. MCKENZIE, Dr. T. M. LOWRY.

Messrs. R. H. PICKARD and J. KENYON.—Optical Rotatory Powers and Dispersion of the Members of Homologous Series.

Mr. T. S. PATTERSON.—(1) The Influence of Temperature and Solution on Rotation. (2) On Optical Superposition. (3) Some Suggestions regarding the Nomenclature of Optical Activity.

(b) *Discussion* on Radioactive Elements and the Periodic Law, opened by Professor F. SODDY.

Mr. A. FLECK.—The Chemistry of the Short-lived Elements.

Mr. G. VON HEVESEY.—Radioactive Elements as Indicators in Chemistry and Physics.

(c) *Metallurgical Papers*:—

Dr. W. ROSENHAIN.—The Amorphous Phase in Metals.

Professor TURNER.—The Volatilisation of Metals in a Vacuum.

Mr. O. F. HUDSON.—The Structural Changes brought about by Annealing certain Metals.

Professor E. COHEN.—Strain Diseases in Metals.

Dr. A. HOLT.—Solution of Gases in Metals.

Dr. C. H. DESCH.—Further Experiments on Diffusion in Solids.

Mr. G. D. BENGORGH.—Metallic Cements.

Mr. F. D. FARROW.—The System Copper Oxygen.

Messrs. R. E. SLADE and G. I. HIGSON.—Temperature of Reduction of Metallic Oxides.

Mr. E. VANSTONE.—Influence of Chemical Constitution on the Thermal Properties of Binary Mixtures.

Mr. F. JOHNSON.—A Study of the Degradation or Enhancement of Quality of Commercial Copper by the Presence of Impurities.

(d) *Discussion* on the Future of British Fuel.

(1) Introduction. (2) Use of Poor Fuel—Coke Oven Recovery Plant. (3) Gas and Oil Fuel—the Bonecourt System. (4) Alcohol as Fuel.

(e) Dr. R. S. MORRELL.—The Saturated Acids of Linseed Oil.

Mr. PRIDEAUX.—The H-ion Concentration in Sea Water. *Reports of Committees.*

COMMERCIAL AND TRADE REVIEW.

GENERAL NOTES.

Combine in the Quinine Trade.

A report recently received from Holland states that a combination of the leading houses in the quinine trade has been formed. Negotiations have been carried on for some years, as the prices of quinine have been most unsatisfactory for the producers of the raw and finished material, but in spite of several agreements on curtailing shipments of bark from Java to Europe the position could not be improved, because the parties concerned did not carry out their obligations. The terms now settled call for the establishment and strict observation of a minimum price of five Dutch cents per bark unit which, it is understood, will necessitate the fixing of a low-limit figure for the sulphate at an equivalent of a shilling. The agreement will extend over three years and fixes the quantity of bark to be produced and taken by salts makers annually at 44,000 cases, or about 1,760,000 ounces of sulphate.

Although the new agreement does not regulate bark shipments, the price maintenance is sure to act as an automatic control of the exports.

Chemically-Prepared Brushes for Metal Polishing.

An article of utility, which might be used with advantage in this country, is a chemically-prepared "wool circular brush" for cleaning and polishing metal articles by machinery. The work done by this brush is very rapid and thorough, and the handling simple. It may be used for the polishing of silver, gold, nickel, aluminium, and other metals; it is also suitable for galvanised articles as it does not injure the metal. Another chemically prepared brush for hand use has been put on the German market. By simply rubbing tarnished metal articles with it they take on a fine polish and appear like new. The brush can be had in all sizes and is comparatively cheap. Its polishing power lasts until it is used up.

Substitute for Platinum.

At a recent meeting of the Rheinische Gesellschaft für wissenschaftliche Forschungen (Society for Scientific Research), Professor Borchers stated that in the Aachen institution, of which he is the president, an alloy was made which is in several respects similar to platinum, particularly as far as its resistance to strong acids is concerned.

New Gelatine Import Regulations.

The American Department of Agriculture has issued regulations which will affect the import trade in gelatine. The order requires that food products not intended for food or drug purposes shall be denatured, and that such consignments be labelled so as to indicate the dangerous ingredients contained in the products.

Although applying to food products generally, this regulation was particularly framed to prevent gelatine and glue with an excessive amount of arsenic, copper or zinc, or other ingredients which made the product unfit for food, to be used for this purpose. The attention of the authorities was aroused by the very heavy shipments of

imported gelatine of this kind, and inquiries showed that a great deal of the gelatine imported "for technical purposes" was put to uses of quite a different nature.

Gelatine containing extraneous matter is a useful adjunct in many lines of trade, such as the photographic industry, the manufacture of artificial leather, artificial ivory, molds for castings, clarifying wines, etc. The new order only applies to *imported* products, as the law does not provide for the denaturing of domestic food substances unfit for food.

New Chemical Steel-Making Process.

At the works of a prominent Munich steel manufacturer, interesting experiments have recently been carried out with a new process, the invention of a Swiss engineer, O. Widmer, of Zürich. According to this process, tool steel is produced from iron by chemical means without re-smelting. Experts of different nationalities were present at these experiments, and they report favourably on the new process and its future.

Curtailment of Naval Stores Production in the United States.

A movement to curtail the production of naval stores is on foot in Florida. The reason for this is the unsatisfactory state of the market for the chief naval stores, *e.g.*, turpentine and rosin. It is proposed to effect a curtailment of about 15% by leaving off operations earlier than usual. A mass meeting to which 1,200 operators have been invited will decide whether the plan will be successful or not.

Wood Alcohol in America.

The energetic campaign against the danger of wood alcohol recently started in the United States has led to a prosecution for violating section 69 of the Sanitary Code. The charge was made against a man for selling paregoric adulterated with wood alcohol. The Committee of Prevention of Blindness has waged a determined war against the growing use of sight-destroying wood alcohol, and their investigations have revealed the surprising fact that fourteen persons in New York were made permanently blind, and four were killed during the past year, either by drinking wood alcohol or inhaling its poisonous fumes.

It is only within the last six years or so that chemists have been able to rectify wood alcohol and eliminate the nauseous taste and odour so that it can be confounded with grain alcohol. Its growing use as an adulterant of cheap liquors and of bay rum, paregoric, flavouring extracts, Jamaica ginger and patent medicines constitutes a real danger to the public, especially as the general ignorance which prevails as to its dangerous nature prevents proper care in handling the article.

Turpentine Adulteration in Canada.

The investigations of the chief analyst of Ottawa, Mr. McGill, have revealed that much adulterated turpentine is sold in Canada. Of 158 samples taken in various parts

of the country, only 106 appeared genuine, while 42 were adulterated with petroleum, and the remainder with different materials. Any action of the Canadian Government against the sale of adulterated turpentine would solely apply to imported goods, as there is no home production as yet. Mr. McGill's investigations will probably lead to further efforts to obtain a good wood turpentine from the extensive raw materials found in the Dominion. Experimental plants have produced very satisfactory results, and it is, therefore, quite possible that the production of turpentine may become a successful Canadian industry.

Prohibition of Food Products in Argentina.

New sanitary regulations have been promulgated by the National Health Department of Argentina regarding the requirements as to imports of foodstuffs. Among the rules affecting the European exporter most of all, the prohibition of the use of the following substances must be mentioned: Boric acid and borates; hydrofluoric, salicylic and benzoic acids and their salts; formol, and saccharine and other sweetening substances.

No reference is made in the regulations as to the date on which they are to become effective.

Synthetic Indigo in Germany.

Great progress has been made in Germany in the manufacture of synthetic indigo. While formerly the value of the annual imports of the natural product averaged £1,430,000, the exports of natural and artificial indigo from Germany in 1912 were 24,811 tons, valued at £2,151,000. Of the exports, 13,044 tons were shipped to China.

Trade Openings in British Colonies.

The Victorian Railway Commissioners, Melbourne, invite tenders for a testing laboratory at Newport workshops at an estimated cost of about £12,650. Particulars may be obtained upon application to the Secretary of the Commission, Melbourne.

A Montreal Company wish to purchase regular supplies of a number of drugs, chemicals, mineral preparations, etc., and would be glad to receive quotations from United Kingdom manufacturers of the same. They include: castor and coconut oil, various varieties of soda and potash, sulphur, alum, dextrines, whittings, dry white lead, oxides, china clay, etc. For further information application should be made to the Canadian Government City Trade Branch, 73, Basinghall Street, E.C.

Chemical Process for Cleaning Silver.

A rapid and easy method of cleaning silver or other metal articles is effected by the use of a novel article which has recently been put on the market by a Continental firm. The "Plaque Köhler Excelsior" process has the advantage of being non-poisonous, clean and inexpensive. A specially prepared plate is placed in a wooden or china container, which is then filled with hot water. Metal vessels must not be used for this purpose, as they prevent the plate from acting on the article to be treated. To every quart of water, 30 gms. of soda have to be added. When placing the metal articles in the bath care must be taken that some portion of each is in contact with the plate. The cleansing takes place in a few seconds. The action of the plate loosens every particle of dirt, which can then be removed with a cloth or brush.

M. L.

Fans and their Application.

Dust has been described as matter in the wrong place, and this definition furnishes in itself a very good argument in favour of a dust-removal plant. In cases where the material is of an inflammable nature its immediate removal reduces the risk of fire and greatly facilitates the cleaning of the rooms and machines. Further, a very appreciable saving can sometimes be effected by making use of the collected dust, as it is obviously futile to collect dust in one place only to discharge it into the open air again. To remove the dust by means of a centrifugal fan is generally the most efficient method, as it permits of the use of hoods, which can be placed at the spot where the dust is being produced without allowing it to escape into the air inhaled by the operators. Another advantage of this fan and duct system is that in carrying away the dust the minimum amount of air is removed, and, therefore, in mills, where the air has to be humidified, less humidity is taken out of the room, while in the case of other factories in winter time the small volume of air exhausted does not increase materially the cost of heating. The accompanying illustration (Fig. 1) shows a dust-removal plant in connection with a textile machine. The compactness of the whole plant is evident. The piping is so arranged that it does not interfere with the accessibility of the machine; the fan itself is bolted up on

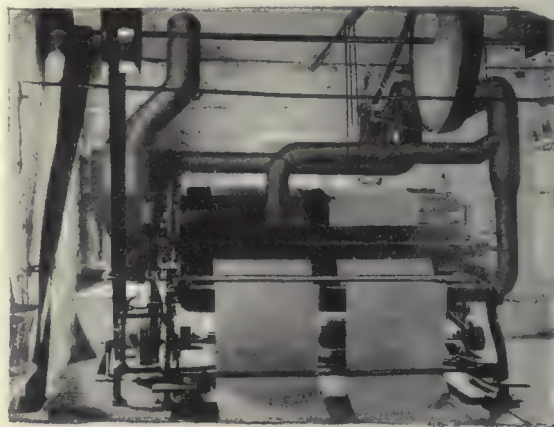


FIG. 1.—"SIROCCO" FAN REMOVING DUST FROM A TEXTILE MACHINE.

the wall, and the cyclone, which separates the dust from the air, occupies but a very small space in the corner of the room. The choice of the fan must be governed entirely by the nature of the dust. For textile dust, wood shavings, and substances of a similar character, a fan should be employed which has broad, spoon-shaped blades on which it is impossible for the dust to settle. Occasionally, however, where the dust is dry and in the form of small particles, an ordinary volumetric fan can be used.

In removing dust the exhaust principle is essential, but where it is a case of removing steam this method would be entirely useless. If an exhaust fan were used, for instance, in a dye-house, it would remove a certain volume of steam, but the conditions in the building itself would become worse, because the exhausted air would be replaced by colder air from outside or from an adjoining room, and this cold air would increase the steamy atmosphere. This is perfectly obvious if one considers that a cubic foot of air at 70 to 75° F. can hold as much as 9 grs. of moisture, while the same quantity of air at half the temperature, viz., 35°, can only hold one-third of the moisture, viz., 3 grs. The most

efficient method of removing steam from a room is to introduce a volume of fresh, warm air into the steam as near as possible to the point where it is given off. The warm air absorbs the steam immediately, and passes away out of the room through suitable openings in the roof. The annexed illustration (Fig. 2) represents the washing-room of a large cleaning and dyeing establishment. Two rectangular ducts extend from each end down the centre of the room. At each end of the ducts a belt-driven "Sirocco" propeller fan is



FIG. 2.—"SIROCCO" FANS USED FOR REMOVING STEAM IN DYEING AND CLEANING ESTABLISHMENTS.

fitted. The fans draw their supply of fresh air from the outside atmosphere, pass it through steam heaters into the duct, out of which the air emerges through outlets provided with deflectors, which give the flow of air a downward direction. This plant removes the steam without allowing it to condense on the roof, thereby preventing the corrosion of the iron girders or the rotting of the woodwork. Further, there is no risk of drops of water falling on and damaging the goods.

Centrifugal fans, which are now extensively used for ventilation purposes, can be obtained in all sizes to suit the various requirements. The "Sirocco" fan, for instance,

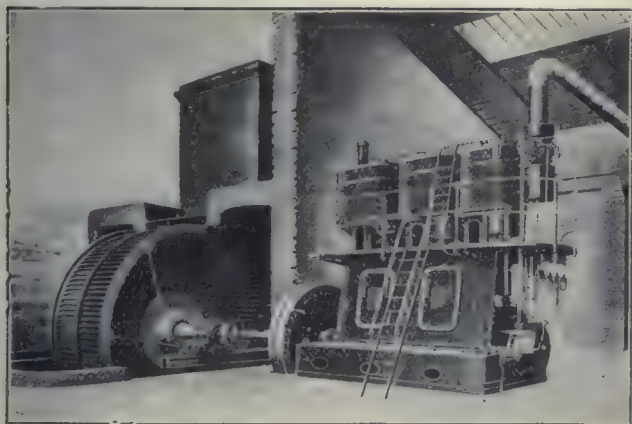


FIG. 3.—DOUBLE INLET "SIROCCO" MINE FAN, 161 INS. DIAMETER, DIRECT-COUPLED TO BELLISS ENGINE.

is built in a large number of standard sizes from 5 ins. diameter, delivering 150 cub. ft. per minute for one-tenth of a horse-power, up to sizes the wheels of which measure 15 and more feet in diameter. The third illustration shows a large "Sirocco" fan which is used for mine ventilation. It is 161 ins. in diameter, and has a capacity of 600,000 cub. ft. per minute against a resistance of 9 ins. water-gauge, for which duty it takes 1,000 H.P.

Market Report.

LONDON.—Under the influence of the holiday feeling the business in the home section of the chemical trade is confined to narrow limits, and the small transactions taking place are prompted more by actual wants than by a desire for speculative purchases. The prospect for the autumn may, however, be considered quite fair, for as soon as the holiday slackness passes away, a general revival of the demand may be confidently expected. This expectation is based on the fact that the great engineering industries are extremely busy, and will probably remain so during the next few months, while the textile industry, also a large consumer of chemicals of all kinds, is looking forward to a time of considerable activity.

As regards the export section of the chemical trade, the future appears rather uncertain, although some people are inclined to feel more confident as to a speedy improvement of the financial position on the Continent. The constant disappointments regarding the settlement of the Balkan troubles tend to make people afraid that it will require some time before permanent peace is restored. How far this will prevent an expansion of trade remains to be seen. The exports of chemicals during the last month (July) have not been influenced adversely by the unfavourable conditions on the Continent. On the contrary, the value of the shipments has largely increased when compared with the same month of last year. This was particularly due to a strong demand for certain coal products (not dyes) such as benzol, toluol, creosote, etc. Glycerine has also added much to the total increase, and the same may be said of soda and potash compounds. The fact that such an increase could take place in spite of distinctly adverse circumstances seems to justify the belief that the future will be more propitious still.

An examination of the chief sections of the market reveals the fact that sulphate of ammonia shows no sign of activity, although a certain firmness is apparent. Producers seem to count on an early revival of the autumn demand, and ask a premium for forward delivery. The prospects of the market are, however, difficult to gauge, in view of the rapidly increasing production not only in this country, but also in the United States and on the Continent. In addition to this, the growing competition of other fertilisers must be reckoned with. The present price for gray 25% quality, prompt delivery, is £12 6s. 3d., while Manchester makers ask £13 5s. for prompt, and 5s. more for forward delivery. An interesting section of the tar products markets is that one devoted to benzols. Although rather quiet at present, there seems to be a great future in store for the article on account of the energetic propaganda which the motor trade press has started. The recent trials with petrol and benzol have proved the greater economy and efficiency of the latter as a motor-car fuel, and its general substitution for petrol seems now only a question of time. The probable effect on the prices of the article can hardly be estimated as yet. At present 50% benzol can be had at 11d. to 11½d., and 90% prompt at 1s. 1d. per gallon. Business in pitch is still very moderate, but the number of inquiries is increasing and the producers take a firm stand. The dry season stimulates the demand for pitch and tar for the treatment of roads, helping to keep stocks low, so that the commencement of the shipping season should see no great surplus of material. The price for prompt is difficult to fix, as some makers are readier to sell than others, but 42s. per ton is about the average asked. Crude carbolic acid remains quiet, and the recent improve-

ment proved only a flash in the pan. On the East Coast the price for 60% quality is 1s. 4½d. to 1s. 5d., and on the West Coast 1s. 3½d. to 1s. 4½d. per gallon. Crystals are quoted 4½d. to 4½d. per lb. Cresylic shares the fate of carbolic acid, being quite neglected at 1s. 1d. to 1s. 2d. per gallon. Naphthalenes are in good demand and quite firm. Fair to good qualities of crude are from £2 15s. to £4 5s. per ton, and refined from £7 10s. to £10, according to quality. The chemical market at Liverpool is under the influence of the Lancashire holidays. Sulphate of copper shows a tendency to rise, making business still more difficult. For January-April delivery the makers ask £23 10s. per ton, less 5% f.o.b. Liverpool, and the spot quotation is £23. Sulphate of ammonia is steadier with numerous inquiries, but little actual business. Cream of tartar is sparsely offered, and tartaric acid firm though in moderate demand. Bleaching powder and caustic soda are a little more difficult to sell, and ammonia alkali (soda ash) is neglected, causing stocks to accumulate. Caustic soda for export, 76 to 77% quality, is held at £10; 70 to 72% at £9 5s.; 60 to 62% at £8 5s.

FINANCIAL NOTES.

At the annual general meeting of the Sumatra Consolidated Rubber Estates, Ltd., the chairman recommended that a final dividend of 5%, making 15% for the year, be declared. 124,630 lbs. of rubber was harvested during the past year, and the selling price is stated as 3s. 8½d. per lb.

The report of the Gas Light and Coke Company shows a net profit of £397,087. £712,387 has been brought forward, making a total available balance of £1,109,474, out of which the directors recommend a dividend at the rate of £4 17s. 4d. per cent. per annum on the ordinary stock, which will absorb £398,742, carrying forward the sum of £710,551.

The British Oil and Cake Mills, Ltd., show a net trading profit for the past six months ending June 30th of £93,867, compared with £52,148 during the previous year. After deducting establishment charges, depreciation, etc., a balance of £66,953 remains, which includes £13,289 brought forward. The interim preference dividend was paid as usual on the 1st inst.

The annual accounts of the Calico Printers' Association, Ltd., show a net profit for the year ending June, 1913, of £374,680, and £7,600 brought forward. The directors recommend a dividend of 3½ per cent. for the year on the ordinary shares, placing £50,000 to capital reserve, etc., and carrying forward £6,170.

The *Times* announces that the Federal Company of Buffalo has declared that the Eastman Kodak Company have infringed the Goodwin Film Patent, and that they have been ordered to account for the profits on the films for the past fifteen years.

TRADE ITEMS.

THE D.S. Pulley Block and Crane Manufacturing Co. send their Booklet No. 78 giving particulars of the D.S. improved pulley block, overhead travelling crane, etc. This well-known company send on approval at their own risk any pulley blocks with the required length of chain. The catalogue also contains a description of their electric runway conveyor, which conveys overhead weights up to two tons at high speed.

E. de Haën, of Seelze, near Hannover, has recently issued a very complete list of reagents (guaranteed pure); special test solutions; standard solutions for volumetric analysis; indicators, dyes, etc., for analytical and microscopical work; solutions for microscopical objects, and test papers. This catalogue is remarkably complete, and is printed in English, although prices are still quoted in marks.

Messrs. A. Gallenkamp & Co., Ltd., send List No. M96, including corrections and amendments to the 6th edition of their General Apparatus Catalogue; List No. 53N of bacteriological apparatus and materials; List No. 58 of improved Jena laboratory glassware; particulars of the "Clifton" Safety Pipette; Sinkinson's automatic apparatus for washing precipitates; Mellor's porosity apparatus; electrically-heated extraction apparatus; and other matters.

SHARE LIST.

Name of Company.	August 25th.	July 24th.
Alby United Carbide	17 2	11 1
Ditto. Pref.	3 1/2 1 1/2	3 1/2 1 1/2
Associated Portland Cement. (10)	7 1/2 7 1/2	6 1/2 7 1/2
Ditto. Pref. (10)	8 1/2 9 1/2	8 1/2 9 1/2
Babcock-Wilcox. Ord. ..	3 1/2 3 1/2	2 3/4 3 1/2
Ditto. Pref.	1 1/4 1 1/4	1 1/4 1 1/4
Bell's United Asbestos ..	1 1/2 1 1/2	1 1/2 1 1/2
Bleachers' Association. Ord. ..	1 1/2 1 1/2	1 1/2 1 1/2
Ditto. Pref.	1 1/2 1 1/2	1 1/2 1 1/2
Borax Consolidated. Pfd. (5) ..	5 1/2 5 1/2	5 1/2 5 1/2
Ditto. Defd.	1 1/2 1 1/2	1 1/2 1 1/2
Ditto. Pref. (10)	10 1/2 11	10 1/2 10 1/2
Bradford Dyers	1 1/2 1 1/2	1 1/2 1 1/2
Ditto. Pref.	1 1/2 1 1/2	1 1/2 1 1/2
British Oil and Cake. Ord. ..	3 1/2 3 1/2	3 1/2 3 1/2
Brunner Mond. Ord.	4 1/2 4 1/2	4 1/2 4 1/2
Ditto. 7% Pref. (10) ..	14 1/2 15 1/2	14 1/2 15 1/2
Bryant and May. Pref.	2 1/2 2 1/2	2 1/2 2 1/2
Calico Printers	3 1/2 3 1/2	3 1/2 3 1/2
Ditto. Pref.	3 1/2 3 1/2	3 1/2 3 1/2
Castner Kellner	3 1/2 3 1/2	3 1/2 3 1/2
Commercial Salt. (2/-)	7/9 8/3	7/4 7/10 1/2
Crossley & Sons. (2)	1 1/2 1 1/2	1 1/2 1 1/2
Ditto. 5% Pref.	4 1/2 4 1/2	4 1/2 4 1/2
Eastman Kodak. (\$100) ..	600 640	580 620
Eley Brothers	1 1/2 1 1/2	1 1/2 1 1/2
Fraser and Chalmers. (£3) ..	1 1/2 1 1/2	1 1/2 1 1/2
Gas Light and Coke. (S.) ..	101 103xd	102 104
Ditto. 4% Pref. (S)	93 96xd	95 98
Greenwich Lino. (1/2)	1 1/2 1 1/2	1 1/2 1 1/2
Harrison and Crossfield. Pref. ..	1 1/2 1 1/2	1 1/2 1 1/2
Imperial Continental. (S) ..	162 167	162 167
Ditto. 3 1/2% Debenture (S) ..	83 85xd	85 87
India Rubber Co. (10)	12 1/2 13 1/2	11 1/2 12 1/2
International Salt	7/- 8/-	5/- 6/-
Ditto. Pref. (12 1/2 pd.) ..	1 1/2 1 1/2	1 1/2 1 1/2
Lever Brothers. 1st Pref. (10) ..	10 1/2 11 1/2	11 1 1/2
Lister & Co. Ord.	1 1/2 1 1/2	1 1/2 1 1/2
Mappin & Webb. Ord.	1 1/2 1 1/2	1 1/2 1 1/2
Neuchâtel Asphalt. (10/-) ..	9 9 1/2	9 9 1/2
Nobel Dynamite. (10)	16 1/2 17 1/2	16 1/2 17 1/2
Ditto. Bearer (10)	16 1/2 17 1/2	16 1/2 17 1/2
Ditto. 5% Pref. (10)	10 1/2 11 1/2	10 1/2 11 1/2
Pears, A. and F. Ord.	1 1/2 1 1/2	1 1/2 1 1/2
Ditto. 6% Pref. (10)	1 1/2 1 1/2	1 1/2 1 1/2
Price's Candle. (16)	35 37 1/2	35 37
Rosario. (5)	9 1/2 9 1/2	9 1/2 9 1/2
Salt Union. (4)	1 1/2 1 1/2	1 1/2 1 1/2
South Metropolitan 4% Standard (S)	108 110xd	109 111 1/2
Ditto. 3% Debenture (S) ..	72 74	71 1/2 73 1/2
United Alkali. (10)	1 1/2 1 1/2	1 1/2 1 1/2
Ditto. Pref. (10)	9 1/2 9 1/2	9 1/2 10
Val de Travers	1 1/2 1 1/2	1 1/2 1 1/2



THE CHEMICAL WORLD

A MONTHLY JOURNAL
OF
CHEMISTRY AND CHEMICAL ENGINEERING

EDITED BY W. P. DREAPER, F.I.C.

"Science moves, but slowly slowly, creeping on from point to point."—TENNYSON.

VOL. II. No. 10.

OCTOBER, 1913.

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" " Abroad 8s. " "

The Birmingham Meeting of the British Association.

(By Our SPECIAL CORRESPONDENT.)

SINCE it is quite impossible within the limits of space assigned to this notice to give an adequate summary of all the papers and subjects of interest to chemists and engineers presented for discussion at the Birmingham Meeting of the British Association, this report is confined to a few selected topics and subjects of special importance to readers of this journal, and many papers and addresses of equal, or even greater value, have been necessarily passed over in silence.

Professor W. P. Wynne's Presidential Address before Section B, dealt with the reforms needed in the training of chemists. The greater part of this address was devoted to a review of the chemical change known as "Substitution" from the standpoint of residual valency, and was highly technical in character. In closing his address, however, Professor Wynne referred to the subject of the higher training of chemists in our colleges and universities, and expressed the following opinion:—

"Two reforms, I venture to think, are needed: the first would avoid early specialisation, which is apt to be disastrous, the second would encourage post-graduate training in directions where the student's inclinations or aptitude may be stimulated and developed. He who is able to convert education committees and private donors to the view that a far better return for the money could be assured if part of the large expenditure on scholarships for matriculated or non-matriculated students were diverted to post-graduate purposes will have done a service to science and the State the value of which, in my opinion, cannot be over-estimated."

The Conservation of our Fuel Supplies.—An important series of papers upon the above subject was read, and very inadequately discussed, in Sections B and G on Thursday and Monday, September 11th and 15th. Below, a very brief summary of these papers is given.

Owing to bad organisation, it is unfortunate that the engineers and chemists did not take part jointly in the discussion, which, in this case probably would have been more satisfactory in character.

Solid, Liquid, and Gaseous Fuels, by Professor Burstall.—After a general introduction discussing the various prime-movers for generating power, and their defects, the author discussed the total available amounts of the various types

of solid and liquid fuel available for this purpose. The annual output of coal, by the mines of the whole world, was estimated to be about 1,200 million tons, while that of crude oil was estimated at 50 million tons. Since it was doubtful if any large oil fields remained undiscovered, it followed that the supply of crude oil was totally inadequate to replace the solid fuel now used for power production. The artificial production of oil fuel must, therefore, be taken in hand as a serious proposition. Up to the present time coal has been gasified with the idea of producing the highest yield of gas, but it was quite possible and practicable to alter the conditions of carbonisation, so as to obtain a high yield of fuel oils and other compounds of great value, including sulphate of ammonia. By the present methods of gasification, a modern gasworks will produce between 11,500 and 12,500 cu. ft. of gas with a calorific value of 550 B.T.U. per cubic foot; 10 gallons of tar; and 25 to 30 lbs. of sulphate of ammonia per ton of coal gasified.

The author is of opinion that the future of fuel treatment in this country lies in the decomposition of the fuel in closed retorts, under conditions which would make the yield of a standard illuminating gas the secondary consideration, and would elevate the yield of by-products into the chief one.

It has long been known that the quantity and quality of the tar is largely influenced by the temperature at which the fuel is carbonised, the lower the temperature the better being the yield and composition of the tarry oils. If the gas and tar are withdrawn from the retort immediately they are evolved, many of the tar oils *after distillation*, can be employed in internal combustion engines for power generation.

These tar oils will yield benzol, light oils of the pentane series, middle oils such as cresylic acid, and, finally, heavy oils of the anthracene series.

The author then sketched out the details of a large scheme of this kind for treating coal at the pit's mouth, the carbonisation units of this scheme, being of 2,000 tons capacity per day. The tar and gas would be taken by pipe-lines to suitable points for their further treatment, the tar being subjected to fractional distillation, in continuous stills (automatically worked) in order to obtain the various light and middle oils from it before sale of the residuum as a liquid or solid fuel.

Such a works will produce from 120,000 to 140,000 gallons of tar per day, and the recovery of by-products from this tar would be regulated according to the relative market price of the various oils obtained.

The gas generated from the carbonisers would not be purified from sulphur, but would be used in its crude state in large 2,000 H.P. gas engines for the generation of electricity, which would be generated at a high voltage, and would be distributed over a wide area from the generating plant at the pit's mouth.

The exhaust gases from these gas engines would then be chemically treated, in conjunction with the liquor from the ammonia plant, and both these impurities of the raw fuel would be recovered as ammonium sulphate. The author admitted that, at present, this scheme was somewhat visionary, but he quite hoped to see it realised within a reasonable time.

Papers and Discussion in Section B.—Professor Armstrong, F.R.S., opened the proceedings in this section on Monday morning, by emphasising the importance of the subject, and the need for prompt action in the conservation of our fuel resources. In his opinion, legislation is certainly required, at the present date, to render illegal the use of raw coal for heating purposes, either in private houses or in works and factories, since only in this way can any reform of our present methods of heating be carried through in reasonable time.

All coal would, therefore, be subjected to destructive distillation before its use, and this distillation would be carried on under the scientific conditions required to obtain a maximum yield of all the valuable by-products.

Finally, our methods of using gas for heating purposes will also require to be reformed, and Professor Bone's method of flameless combustion would, doubtless, be one that would receive wide and extended application in the near future.

Dr. George Beilby, F.R.S., of Glasgow, contributed a paper on the "Low Temperature Carbonisation of Coals," to the same discussion. After considering the advantages offered by this method of treatment and discussing some of the causes of the failure of the "Coalite" system, the author gave an account of the practical progress made at the works of the Cassel Cyanide Co., in Glasgow, with the design of an improved retort and process for carrying out the low temperature carbonisation of solid fuel.

After numerous trials, and some failures, an apparatus has been designed which would coke 15 tons of coal per day, at a temperature between 400° and 450° C. This apparatus is continuous in its system of working and will convert cheap non-caking small coal either into a fuel suitable for gas-producer work, or into a smokeless fuel for domestic use, while at the same time it enables one to recover all the valuable by-products of the raw fuel from the evolved gases. The thermal value of the gas obtained from the apparatus is 850 B.T.U. per cubic foot.

In concluding his paper, Dr. Beilby stated that the chief difficulties at present were due to the caking of the coal, and to the breaking down of the charge, by dropping from shelf to shelf into coke no larger than the ordinary coke breeze. These were serious but not fatal defects. In order to render the coke after treatment in the carbonisers fit for household use, it was, therefore, necessary to briquette it, but for gas-producer work the coke could be used exactly as it came from the carbonising plant. The briquettes were manufactured by using 7% of pitch as binding material, and they were sold in Glasgow for household use at the rate of 20s. per ton. It was quite possible, however, that as the apparatus and process were improved, that this price might be lowered; and it was not given as indicating the final value or price of the domestic fuel produced by the process.

Finally, the author stated that the really significant points in any successful process were covered by the economic and engineering questions: Can an outlet be found for the low temperature coke—and can a satisfactory apparatus be devised?

The apparatus must be constructed in fairly large units; it must be automatic in working, and it must operate with the smoothness and regularity of the best types of automatic stoking machinery, and with a minimum of manual labour or of skilled supervision. The gases and vapours from the distillation must also be carefully preserved from loss or damage, either through leakage of gas outwards, or of air inwards. The necessary heat must be also applied as to cause no deterioration of the material of which the apparatus is constructed, and the heating of the charge must of course be economic.

The author stated that he was not without hope that an apparatus would be produced which would tempt the orthodox gas engineer to give low temperature carbonisation a serious trial on its merits.

The existing gasworks certainly ought to be the natural nursery for the development of such a scheme, and Dr. Beilby added that the promoters of the Glasgow experimental plant had already received an encouraging offer to try their apparatus from the head of one of the leading gas companies, but they were determined not to allow the process and carboniser to leave their own hands until they were perfectly satisfied that it would work satisfactorily.

Dr. Wheeler contributed an important paper on the "Composition of Coal." The author stated in this paper that coal contained two main types of compound, the first of which, on heating, decomposed easily and yielded the paraffin series of bodies, while the second type decomposed with difficulty, and gave rise to hydrogen and carbon as its products. His investigations have convinced him that the second type of compound was derived from the cellulose constituents of the vegetable matters from which the coal had been formed, while the first type was derived from the resins and sap of this original vegetable matter.

A method of separating these two types of bodies as they exist in coal was then described. This method depending first upon the extraction of the powdered sample of coal with pyridine, and secondly upon extraction of the pyridine solution by aid of chloroform. By this method of treatment, the coal can be separated into the two classes of body referred to above, and a rational, or proximate analysis of the fuels be obtained in a comparatively simple manner. The results of such an analysis would be found much more valuable than the mere elementary analysis giving the percentage of carbon, hydrogen, oxygen, and nitrogen when determining the value of the fuel for many industrial purposes.

A further development of this method of examination of the fuel was the discovery that the resinous constituents of the fuel emitted chemically active rays which affected a photographic plate, while the other class of constituents gave negative results under similar conditions.

Some idea of the rational composition of a piece of coal could be obtained, therefore, by merely allowing it to rest with a flat surface in contact with a photographic plate for 12 hours in a dark place, and by then developing the latter as a negative. The author closes his paper by stating that it was possible this method of examination would prove of value in determining the coking properties of a raw fuel.

FACTS AND THEORIES RESPECTING SYNTHESIS BY ENZYMES.

By W. M. BAYLISS, M.A., D.Sc., F.R.S. (Professor of General Physiology in University College, London).

It is unnecessary to give evidence as to the general fact that synthetic processes take place under the action of enzymes. So many cases of very various chemical nature have been recorded that the actual occurrence of such processes is, at the present time, beyond doubt.

On the other hand, conflicting views are held as to the mechanism of such reactions. Some hold that there is a distinct class of enzymes capable of synthetic action only and another class which is capable of hydrolytic action only. Other investigators believe that, when the reaction results in the formation of an optically active substance, this product is not the same as that which is hydrolysed by the enzyme, but its optical isomer. Moreover, there are difficulties with regard to the position of the end-point, or equilibrium, some observers doubting the existence of a true equilibrium altogether, while others deny that it is controlled by the law of mass action.

I wish to call attention, in the first place, to two, or rather three, particular cases, of recent investigation, where the conditions and results are of a simple nature, uncomplicated by side-reactions or uncontrollable phenomena. Afterwards, as far as space will allow, brief reference will be made to the explanation of results which seem to contradict the conclusions drawn from the simple cases.

It is well known that a reversible reaction, such as that of ethyl acetate and water, comes to a state of equilibrium when the four components of the system are present in a definite relative proportion, and that this position is identical whether it is approached from the side mentioned or from that of acetic acid and alcohol. At the equilibrium position the two reactions of hydrolysis and synthesis are proceeding at equal rates; since the relative masses of the two sides of the equation are not, as a rule, equal, it follows that the velocity constants of the two reactions must be unequal. At the equilibrium position, in fact, the smaller velocity constant is counterpoised by greater active mass of reagent. Left to themselves, such reactions proceed so slowly that they are usually incapable of detection in a reasonable time, but they can be enormously accelerated by the addition of a catalyst of some kind. In the case of the alcohol-acid-ester-water system, hydrogen ions form the most frequently used catalytic agent.

It is important to note that the equilibrium position is practically the same whether it is brought about rapidly by the action of a catalyst or arrived at slowly by the spontaneous process. Now, what is the conclusion to be drawn from this fact? If the catalyst caused one only of the two opposite reactions

to be accelerated, say the hydrolytic one, leaving the other one unaltered, the equilibrium position must be changed, so that the system at the end of the reaction must consist practically of hydrolytic products only. Conversely, if the synthetic reaction only were affected, the final state of the system would consist almost entirely of synthetic products. Imagine two people walking slowly towards one another. They will meet somewhere about midway between the two places from which they start. If one of them runs, he will meet the other before he has got more than a few steps from home. If both run, and at the same rate, they will meet midway as in the first case. The fact, therefore, that the equilibrium position is unaltered by the presence of the catalyst shows that *both* the reactions have been accelerated and, in this particular instance, to an equal extent. Experiment shows that this is the correct interpretation of the phenomenon; in fact, while acid in dilute solution is used for purposes of hydrolysis, it is also used, especially in the concentrated form, as a routine method of esterification and for the synthetic production of certain glucosides, etc.

A further point, which will, I think, have been made clear by the above consideration, is that it is not necessary that both the reactions should be equally accelerated by the catalyst. Whenever the equilibrium position is found to be, under the influence of a catalyst, anywhere except at practically complete hydrolysis or synthesis, *both the reactions must have been accelerated*. This is an important fact to bear in mind when dealing with enzymes.

Enzymes are generally considered to be catalysts of a special kind; indeed, it is difficult to see what else they could be. Moreover, the majority of the reactions in which they play a part are known to be reversible. It seems, then, to be impossible to avoid the conclusion that an enzyme must accelerate both hydrolysis and synthesis whenever we find experimentally that the position of equilibrium is at any stage other than that of complete hydrolysis or synthesis. In all the three cases which I propose to consider this end-point was actually found to be nearer to the middle than to either end of the reaction, and the conclusion was drawn, with justification, that the enzyme concerned had brought about both hydrolysis and synthesis. Another conclusion that seems to me to be inevitable is that, whatever new enzyme we choose to postulate, this enzyme, if capable of hydrolytic action, must also be capable of synthetic action and *vice versa*. So that the assumption of a special synthesising class of enzymes is, to say the least, entirely superfluous.

The three cases to be referred to especially are : amyl butyrate, with lipase, in the experiments of Dietz ; the glucosides of various alcohols, with emulsin and maltase, in the experiments of Bourquelot and Bridel ; and the glucosides of glycerol, with emulsin and taka-diastrase in my own experiments, which actually formed, although unknown to me at the time when they were begun, a continuation of the last work done by van't Hoff.

The law of mass action, applied to the equilibrium of reversible reactions, is usually expressed thus (taking the ester reaction as an illustration) :—

$$K = \frac{(\text{ester}) \times (\text{water})}{(\text{acid}) \times (\text{alcohol})}$$

where K is the equilibrium constant and the factors in brackets express the concentrations of the four components. We see at once that increase of water involves the decrease of ester in order to keep the fraction at a constant value. In other words, the more water present, the less of the synthetic product. If it is required that the equilibrium position shall be in a convenient place for investigation, it is necessary to diminish considerably the amount of water present, as compared with the usual experiments on the hydrolytic action of enzymes. In the experiments of Dietz this was reduced to about 10%, which is indeed as much as the amyl alcohol dissolves ; in those of Bourquelot and Bridel, who intended to synthesise salicin, ethyl alcohol in a strength of about 85% was used as solvent instead of water, with the result that ethyl glucoside was formed, and the attention of the investigators was diverted to the alkyl-glucosides. In my experiments a similar result was obtained. I wished to obtain synthesis of arbutin by the agency of emulsin, and, using glycerol to decrease the concentration of water, found that glycerol glucoside was formed. It is to be noted that amyl alcohol, butyric acid, glucose, glycerol and various primary alcohols are all substances of simple, known constitution and without injurious action on the enzymes concerned.

The experiments which were made to determine the effect of the amount of water present showed that, quite in agreement with the law of mass action, the greater the concentration of water, the nearer was the equilibrium point to the stage of complete hydrolysis. It is also of interest that the time taken to reach the end-point was shorter the greater the water content. Most experiments were made with a sufficiently low concentration of water to enable a considerable amount of the synthetic products to be formed, but not so low as to prolong unduly the length of time required for equilibrium to be attained. This time usually amounted to a week or ten days, dependent on the temperature. The actual end-point is only reached asymptotically, but the course of the curves shows clearly where it will be.

The *equilibrium is a genuine one*, since the same position is obtained from either end. It is, moreover, independent of the amount of catalyst present. The enzyme itself, therefore, does not form a constituent of the final chemical equilibrium, as had

been supposed by some of the earlier observers. Reference may also be made here to the view of Rosenthaler, that hydrolysis and synthesis are effected by two different enzymes, at least in the case of emulsin. It follows from this hypothesis that, when an equilibrium is reached at any position other than complete hydrolysis or synthesis, the two kinds of enzyme must both be present, and that the particular composition of the system in equilibrium depends on the relative proportion of these two oppositely acting enzymes. At the outset it is difficult to understand how two different enzymes should always be present in the same relative amount in all sorts of various preparations of emulsin, as must be the case since the equilibrium position is found to be identical, and, in fact, it is stated by Rosenthaler that they are differently sensitive to heat, the hydrolysing one being the less stable. On testing this question experimentally, I found that identically the same equilibrium point was reached by the use of a normal and a heated preparation of emulsin. The latter, naturally, acted more slowly, owing to partial destruction, as was shown by Tammann. There are also, according to Rosenthaler, some other methods by which a separation of the two emulsins can be effected, but, on repeating these experiments, I found invariably that the results described were due entirely to partial precipitation or destruction of the enzyme, and no evidence could be obtained that either effect was present without the opposite one.

The *actual position of the equilibrium* was found to be, in all the three cases, different from that attained under the action of acid, being nearer to the position of hydrolysis ; in other words, the hydrolytic reaction was slightly more accelerated than the synthetic one. In Dietz' experiments the system in equilibrium under the action of acid contained 85.5% of ester, under lipase only 75%. Now, at first sight, there is an apparent difficulty here, in that the possibility seems to be given of evading the second law of thermodynamics, by changing from acid to enzyme and back, isothermally. It seems clear that energy must be expended unless the reaction is absolutely thermo-neutral, and that the energy must be afforded by the catalyst. The real active catalyst, however, in the case of an enzyme action, is extremely minute, and it does not seem possible that any considerable chemical energy could be obtained from it. On the other hand, it must be remembered that, although the hydrolytic reactions with which we are concerned are not quite thermo-neutral, they are very nearly so ; hence a very small amount of energy is required to effect a change in the equilibrium position. Again, enzymes are in the colloidal state, so that the reaction takes place in a heterogeneous system, at all events in a micro-heterogeneous one, and it seems not at all unlikely, as Herzog suggests, that surface energy of some kind may be capable of accounting for the result. The fact that enzymes act by adsorption on their surfaces comes out clearly in the experiments with which this article deals. Lipase and emulsin were found to be active in liquids, such as strong

alcohols, in which they are completely insoluble and can be filtered off, while the filtrate shows no enzymic activity whatever, even when concentrated.

The reason why it was impossible to obtain salicin or arbutin in the experiments quoted is shown by van't Hoff to be due to the fact that glucosides of tertiary alcohols are very difficult to synthesise; their equilibrium points, even in saturated solutions, being almost at the position of complete hydrolysis. This fact, of inherent difficulty of reaction has not been sufficiently taken account of in attempts to obtain synthesis by enzymes, nor, indeed, in investigations on the action of enzymes in general.

Brief reference should be made to the dilatometer experiments of van't Hoff on the salicin and arbutin systems, since they have been cited as proving the non-existence of an equilibrium in any sense. The exact meaning of these experiments is difficult to grasp, especially since the description of the theory on which they are based is much abbreviated, but if the statements of van't Hoff be read with care, it will, I think, be clear that the object of the experiments was to see whether the position of equilibrium in glucosides of tertiary alcohols was, as theory predicted, very near to the state of complete hydrolysis, and that the experimenter himself did not regard them as proof of total absence of the synthetic side of the reaction. In fact, in a footnote, he refers to an experiment in which he thinks it likely that synthesis did occur. In repeating some of the experiments I found that contraction, the sign of hydrolysis, occurred even when the products of hydrolysis alone were present, that is when no more hydrolysis was possible. As they stand, they cannot be used to prove anything more than that hydrolysis of salicin occurs in a very concentrated solution of the products of hydrolysis.

Nothing has been said as yet with respect to the nature of the glucosides formed in the experiments of van't Hoff, Bourquelot and Bridel, and myself. There are, as shown by Fischer, two series of optically isomeric glucosides, conveniently known as α - and β - respectively. The former are hydrolysed by maltase, the latter by emulsin. Which then does emulsin synthesise? In all the experiments of which we speak here it was the β -form that was produced. It is, indeed, difficult to understand how any equilibrium position could be reached unless the same isomer were hydrolysed and synthesised, since emulsin is supposed to have no hydrolytic action on the α -glucosides, so that a reverse reaction is impossible. We have, as yet, no satisfactory explanation of the formation of the opposite isomers in the experiments of Frankland Armstrong on the synthesis of maltose by emulsin and maltase. It seems as if some process of recemisation must have happened in the separation of the sugar after the reaction itself had come to its equilibrium.

The various alkyl-glucosides in Bourquelot and Bridel's experiments can easily be isolated in the crystalline state by evaporating the digest to dryness and extracting with ethyl acetate. The glucoside alone goes into solution and can be recrystallised

from ethyl acetate. The possibility of change seems excluded in so simple a process.

Bourquelot and Bridel have also succeeded in preparing α -methyl-glucoside by the use of maltase from yeast in place of emulsin, and I have myself obtained the corresponding glycerol-glucoside by the action of the maltase of taka-diastrase. Here again we obtain the same optical isomer as that hydrolysed. It is important to remember that, in Croft Hill's experiments, although the sugar isolated did not appear to be maltose, yet it was hydrolysed, in dilute solution, by the same preparation of enzyme under whose influence it had been formed. The same statement applies to the "isolactose" of Fischer and E. F. Armstrong, obtained by the action of lactase on a mixture of glucose and galactose.

There remain to be mentioned three cases where it was supposed that a special form of synthesising enzyme was active. The first is that in which anti-emulsin, produced by injection of emulsin into rabbits, caused synthesis of lactose, described by Beitzke and Neuberg. I found that no anti-emulsin is formed under these conditions, merely a "precipitin" for the foreign plant protein present in the emulsin injected, and that there is no satisfactory evidence that any synthesis of lactose occurred. In fact, although this hypothesis of the synthetic action of anti-enzymes was accepted by Euler, the original authors retracted it in a second paper in favour of the synthesising emulsin of Rosenthaler, for whose existence also no proof has been given, as I showed in the experiments referred to above. The second case is the "synthesis of paranuclein by pepsin" described by Brailsford Robertson; here the reaction turns out to be a colloidal precipitation phenomenon. In fact, the substance formed is neither due to a synthetic process in the chemical sense, nor is it "paranuclein," nor is it produced by pepsin itself, but by some impurity in scale preparations of the enzyme. The third case is the supposed existence of an enzyme, in extracts of yeast, which synthesises hexose-phosphate, but is incapable of hydrolysing it. Although this substance has been described by Euler, it does not seem to be in agreement with the results of Harden and Young, who found, in apparently similar extracts, an enzyme which hydrolyses the hexose-phosphate. Probably the same enzyme has both activities, but further investigation is required. The details of these three sets of experiments are beyond the limits of this article.

There is, in short, no convincing evidence that there are any enzymes capable of either hydrolytic or synthetic action alone. The suggestion of Euler to make use of the termination "ese" for the latter kind of enzyme is superfluous and may be allowed to drop. In any case, it could scarcely be regarded as a satisfactory one, owing to the similarity of its pronunciation in German to the English pronunciation of "ase."

We find then that, in simple systems easily investigated, the action of three enzymes, lipase, emulsin and maltase, follows, without exception, the laws of catalysis by a single agent. The conclusion

is, as it seems to me, justified that, whenever we meet with apparent deviations from such laws, instead of inventing new enzymes or making assertions that the laws of physical chemistry do not apply to enzyme action, we should endeavour to find the reasons for the divergence. Until the impossibility of explanation on these lines has been demonstrated it is more in accordance with scientific method to hold provisionally the application to all enzymes of the laws which can be shown to apply to so many, especially when these cases are such as to be capable of direct investigation. Some of these have been dealt with in this article. In the interest of clear conceptions the name "enzyme" should be denied to any substance which does not obey the laws of catalysis.

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THE RETTING OF FLAX AND HEMP.

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At the present time there is a growing desire on the part of English agriculturists to return to the cultivation of flax and hemp; especially is this manifest in Yorkshire, Somerset, Kent and the East Central counties, where at one time the cultivation of hemp and line—flax grown for fibre—figured largely in agricultural practice. It is, however, realised that whilst no real difficulty is to be apprehended in raising good line, a market does not exist in this country for the harvested crop, and farmers are reluctant to engage in the troublesome processes of fibre separation. The opinion is freely expressed, that if the crops could be taken off the farmer's hands and dealt with at a centre, the more complicated processes of retting, breaking, scutching and hackling, could be carried out profitably, and great benefit would accrue to English agriculture.

Quite recently a general account of the manner of raising good flax crops, and of their subsequent treatment, has been published in *Science Progress*, 1913, 28, wherein the possibility of reviving the flax industry in this country is considered in the light of a report presented to the Development Commissioners in 1912. The conclusions arrived at from the evidence of that report are, that the after processes of fibre separation do not fall properly within the province of the agriculturist, and that the prospects of successfully centralising those operations are, at the present time, sufficiently encouraging to warrant preliminary trials being made in certain districts where the art of handling the crops has not been lost entirely. It is of special interest now to observe in the *Times* of June 17th, that a recently formed society—"The British Flax and Hemp Growers' Society"—propose taking active steps to give effect to such a scheme for centralising and standardising the after processes of fibre separation.

When considering the form such trials should

take, it is at once agreed that the real difficulty centres round the precise method to be adopted for separating the fibre from the straw. Very many processes have been proposed and tried, but they have soon fallen into disuse. Whereas great advances have been made in the linen trade, the processes by which the raw fibre is obtained for the spinner, are substantially those which have been handed down for many generations.

Since about 1820, when steam-driven flax spinning machinery became commercially successful, very great achievements have been effected in all kinds of machinery for dealing with flax, culminating in the *automatic hackling machines* which are almost human in certain of their movements. Compared with these remarkable advances made on the engineering side of the linen industry, it is surprising to find that the present methods of fibre separation and subsequent preparation for the spinners are hardly different from those practised in the Middle Ages.

It cannot be said that this is due to lack of enterprise on the part of those engaged in the industry, nor to neglect by those who occupy themselves with scientific research. There has grown quite an extensive literature dealing with the problems presented by the economic separation of vegetable fibre, although it appears that insufficient attention is paid to these chronicles by those who, from time to time, devise "new" methods of fibre separation. Probably this is due to the information being scattered among journals which are not easily accessible.

Before referring to the means which have been tried and those which are now adopted for separating the fibre from flax (*Linum usitatissimum*), and hemp (*Cannabis sativa*), it will be convenient to mention that the fibre which makes these commodities so valuable is a long bast fibre which is arranged in

groups or bundles just beneath the epidermis and the cuticle. These long fibres are themselves made up of chains of short fibres which are held together and in position by an intercellular gum or resin, which is known as *pectose*. The successful separation of fibre from these plants depends upon the isolation of the long fibres without going so far as to weaken the binding between the smaller individual fibres composing them.

At the present time, the general practice in all flax growing countries of effecting this *pectose* decomposition is to follow a method which has been in vogue for centuries past, and which is referred to in the writings of W. Blith, 1652, Thos. Hale, 1758, and in many other old works on husbandry. It consists in allowing the stems to slowly rot, either by submerging them in water or by allowing alternate dew, sunshine and rain to carry the decomposition forward until the fibre is easily detachable from the woody part of the stem. These operations are now known by the name of "retting," the former being called "water-retting," and the latter "dew-retting," and, as practised to-day, present little departure from the early accounts referred to.

"Dew-retting," is the simplest of all methods of retting which have been devised, as it only necessitates spreading the straws thinly over the ground in regular rows where they are allowed to remain for about six weeks, during which time they are occasionally turned over. As might be expected from this treatment, the fibre so obtained is generally of very low quality: nevertheless, enormous quantities of dew-retted flax and hemp are annually prepared in Russia, Austria-Hungary and other countries.

The other method of retting referred to, namely, "water-retting," as practised in Ireland, Russia, Silesia, France and parts of Holland and Belgium, is still conducted on very primitive lines. After removing the seed the stems are tied up into bundles and packed closely into pits containing water which are specially reserved for the purpose. A light covering of straw is put on the top of the bundles, and upon this a suitable weight of stones is arranged so as to keep the whole mass uniformly submerged during the retting period. During summer weather the usual time for steeping flax is from ten to twelve days, and when the adjudged point has been reached the straw is carefully removed from the retting pond and is either spread over grass land, or opened out and stood upon end to dry. In certain other districts a somewhat different practice obtains; for instance, in the south of Holland and East Flanders the bundles of flax are kept submerged by covering the entire mass with mud, whilst in Friesland the bundles are merely floated upon the surface of the water.

Although many people express the opinion that retting is best conducted in stagnant water, there can be no doubt that the best flax on the market comes from the neighbourhood of the River Lys, near Courtrai, where the practice is followed of twice submerging the flax in the river—a method

known as "double retting" or "Lys-retting." For the production of high-class fibre, this method stands before all others which up to the present time have been tried. It is a practice which originated in the neighbourhood of Courtrai about the middle of the last century, soon after it had been discovered that retting is primarily a fermentation process.

The universal practice in the Lys district at the present day is to make up the straw carefully into bundles and pack them vertically into wooden crates—called "ballons"—which are then anchored to the river bank and launched in the water where they are maintained sufficiently submerged by arranging large stones on the top. Great care is exercised to keep the straw clean, the "ballons" being lined with sacking as a protection against the entry of mud and dirt from the river. During the summer months the temperature of the river water is about 20° to 25° C., and the first retting occupies nearly a week. After that time the straw is taken to an adjacent field where it is dried, then made up into bundles again and reimmersed in the river. The second retting period is usually somewhat shorter than the first, the time required being about four to five days; it is, however, determined by carefully examining the straw at frequent intervals. The straw is then dried again and stored under cover for some time before it is scutched.

The Belgian workers have undoubtedly acquired remarkable skill and judgment in retting and handling the wet stems, but it is probable that their singular success is to be attributed in large measure to the character of the River Lys—to its sluggish movement, to the organic matter it carries from towns higher up its course, and also to the fact that large quantities of flax are annually retted in its waters.

Like other fermentation processes, retting may be accelerated by raising the temperature of the water in which the flax is steeped. This fact led Schenk, in 1846, to devise a method of retting in water artificially warmed to 32° C. in tanks constructed for the purpose but otherwise based on the practice which generally obtained at that time. Since then quite a number of similar methods have been proposed, and it is of interest to find recorded that in 1853 as many as twenty such retteries were in operation in Ireland; and of the flax factories in England, those which had adopted the method of retting in tanks of warmed water were the last to close down during that period of depression from which the English flax industry has never recovered. A great defect in the process of tank-retting as conducted at that time was the inability to control the retting process, considerable difficulty being experienced in maintaining the water at the required temperature so that lack of uniformity characterised the finished product. During recent years, however, improvements have been effected, and retting in warm water has been placed on a more certain footing. Several establishments have been organised and worked on these principles, and so far as the retting is concerned, generally speaking, they have met with success, the cause of failure being due in

many cases to want of capital or to injudicious expenditure in the first instance, which not only ruined many of them financially, but brought the method into ill-repute among commercial people. At the present time factories seem to be successfully operating at Bruges, Courtrai, Oenkerk and other places.

Early in the nineteenth century retting was studied from the biological side, and it was soon established that it was primarily a fermentation process. It was not until much later, however, that definite views were formulated regarding the nature of the process. In 1868, Kolbe came to the conclusion that it was a pectin fermentation process, whereby the insoluble intercellular substance becomes removed, thus allowing the fibres to be separated. Although this view was warmly contested by Tieghem and others, who held the opinion that the process involved fermenting away cellulose, the subsequent researches of Friebes and of Omelianski have at any rate established the fact that the flax stems themselves carry a definite anaerobic bacterium which is active towards the intercellular substance, and which is inactive towards cellulose. This view is held at the present day, although it is sometimes suggested that more than one organism is concerned in the change and that others are present which do effect a decomposition of cellulose.

Doumier, in 1899, advocated a method of retting in warm water to which had been added bacteria isolated from retting liquor. Stormer, 1904, and Hoffmeister, 1905, have shown that certain retting organisms are not difficult to isolate, and the latter investigator has quite recently (1910) advanced our knowledge of the retting process by carefully studying the relative activity of different bacteria occurring on flax stems. Of those which he isolated and examined, *Bacterium megatherium* was least active, the most active being *Bacillus subtilis*, *Bacillus patrificus coli*, and *Bacillus fluorescens liquefaciens*. When however, a combination was used of the last-named bacillus and *Saccharomyces glutinis*, retting was observed to proceed even more rapidly than with *Bacillus fluorescens liquefaciens* alone, notwithstanding the fact that *Saccharomyces glutinis* itself was found to be without action on the flax stems.

In the light of these and other researches, attempts have been made to accelerate retting by adding to the water certain salts which would presumably encourage the development of bacteria or by the addition of urine as was advocated by Blet. Retting has also been attempted on a commercial scale by making use of cultures of the isolated organisms, but, so far, little success has rewarded these endeavours; indeed, at those factories where retting on these lines was attempted, the method has been abandoned in favour of warm water retting installed in such a way that the actual retting process may be suitably controlled.

Apart from the methods of retting already referred to, and which are essentially modifications of the natural process of retting, other processes of fibre separation on quite different lines have been

devised which, for that reason, are known as "artificial" retting.

In 1852 Watts patented a process which involved submitting the straw to the combined action of steam and hot water in specially constructed steam-tight chambers. This method was investigated and favourably reported upon by the Belfast Flax Improvement Society, who regarded it as effecting a great saving of time and economy of fibre, whilst at the same time the usual nuisance of disposing of noxious-smelling retting effluents was entirely avoided because the remaining liquid was inoffensive. It was, however, soon shown that the disintegration of the flax stem proceeded not from the action of the steam *per se*, but from the hot water condensed therefrom, which dissolved the albuminous substances of the straw. Based upon this fact, Buchanan devised an automatic arrangement for repeatedly submitting the straw to the solvent action of hot water, kept below 82° C., at which temperature albuminous solutions coagulate. Another process making use of hot water and steam was that proposed and tried by Dogyu, the straws being in this case submitted to the action of hot water contained in a closed vessel heated to 150° C. for half an hour for the purpose of converting the pectose into pectin, and then to the action of dry steam at 150° C. for a further period of half an hour. A method similar to this was proposed by Passy in 1886, which required the flax straw to be heated with steam under pressure to 150° C. for 1½ hours when the fibre may be easily detached.

Of the many plans which have been devised for separating the fibre from flax and hemp, so as to avoid the operation of retting, quite a large number of them are based upon the use of such materials as soap, caustic soda, mineral acids, phenol and other chemicals. Caustic alkali was extensively used by Lady Moira, as early as 1775, for the production of so-called "flax-cotton," and from that time dates a long list of processes which make use of either caustic soda or caustic potash, some being conducted at ordinary temperatures and pressures, whilst others require that both should be above the normal.

Terwangen proposed steeping flax stems in cold water to which wood ashes, charcoal and chalk were subsequently added; and, in 1880, Thümmeler and Seidel suggested as a commercial process that flax and hemp stems should be submitted to the action of steam and hydrogen chloride, afterwards immersing them in milk-of-lime, then in a bath of caustic soda followed by steeping in a bath of hot water containing soft soap, then a bleaching bath followed by several other baths, after which the material was dried and rendered soft by adding small quantities of glycerine.

A method patented by Lee in 1812, necessitated boiling the flax straw with a soap solution, and this method was taken up by the "Irish Linen Board," who endeavoured, at considerable cost, to introduce it into the Irish flax districts. Quite a number of processes similar to this have been proposed and are still being tried for effecting the separation of fibre

from flax, hemp, nettles, and other plants; some of them require, besides soap, the addition of ammonia chloride and borax, others a considerable quantity of caustic alkali. Apart from the question of cost, the main disadvantage of these methods lies in the fact that the fibre produced is harsh and dry, the fibre being deprived of the oily substances which are naturally carried, and which give "nature" or "spinning quality" to the fibre.

A somewhat different method has been advocated by Chevalier Claussen (1852), who adopted the plan of boiling the green stems with a very dilute solution of caustic soda (about 0.5%) for some hours, and then transferring them to a dilute solution of sulphuric acid. An early patent of Baur's (1884) also involved treatment with acid, namely, dilute solution of hydrochloric acid, but this method of fibre separation he afterwards abandoned (1892) in favour of heating the stems under reduced pressure in specially constructed vessels for several hours with dilute sulphuric acid followed by a solution of alkaline carbonate, and finally with water.

Nicolli and Smith, in 1891, patented a method of separating fibre from flax and hemp which required the stems to be immersed in a cold solution of sodium phenolate for one or two days. Although this method is expeditious and simple to carry out, like all other so-called "artificial" methods of fibre separation, it cannot be said to have proved successful when attempted on a commercial scale.

A step in the direction of preparing by chemical means a fibre possessing "spinning-quality" has recently been made public by Silberrad, who, in 1911, patented a process of fibre separation which involves treating the straw with a solution containing alkali, soap and sulphuric acid at a temperature 60° to 100° C. This causes the latter substance to become hydrolysed, and there is deposited on the fibre a substance resembling the oily materials naturally in the plant.

Having briefly reviewed some of the methods of naturally and of artificially separating vegetable fibres, it only remains to observe that relatively little attention seems to have been given to methods which depend upon the removal of the woody part of flax straw by mechanical means only. In the case of hemp, purely mechanical means of separating the fibre are successful, and there is a good demand for the fibre so obtained. Some trials made with dried flax straw some two or three years ago point to this as being a line of work which would lead to the successful preparation of a fibre well suited to the requirements of twine merchants.

It must be observed that there is a good demand for "green" or unretted hemp fibre at a price which is sufficiently high to make it scarcely worth while to do more than collect the stems at a suitable centre and remove the wood from them by mechanical means only. In the case of flax, however, it appears to be the best policy to aim at retting at a centre in tanks of warmed water under conditions which admit of the process being standardised and controlled to reproduce as far as possible the best conditions of Lys-retting.

Eighth Report of the Royal Commission on Sewage Treatment and Disposal

(Including any Liquid from Factories or Manufactures).
Standards and Tests: Vol. II., Appendix, by Dr. G. McGowan, Mr. C. C. Frye, and Mr. G. B. Kershaw.
1913. Price 2s. 9d.

By S. RIDEAL, D.Sc. (Lond.), F.I.C.

It will be remembered that the first volume of the Eighth Report was published in November, 1912, and attracted the greatest interest from its being a summing up of the Commissioners' deductions from their fifteen years' work in collecting evidence and in arranging researches on special points. We must welcome these publications as a digest of our improved knowledge on a subject which, although really urgent and pressing, has undergone delays of inquiry and legislation for nearly 100 years. For in England the first Board of Health was appointed in 1831, as a result of the cholera scare, followed by Royal Commissions in 1843 and 1857, Rivers Pollution and Royal Sanitary Commissions between 1865 and 1874, and a Metropolitan Sewage Commission in 1884. Their recommendations were in great part adopted by several Acts of Parliament (Public Health, 1848, 1872 and 1875; Local Government, 1858 and 1861; Sanitary, 1866; Pollution of Rivers, 1876), which, as we know, have not worked satisfactorily and have led to heavy expenses in the law courts. Yet England has been generally recognised as the pioneer in this branch of sanitation, possibly from the density of her population—the Massachusetts experiments did not begin till 1887.

Our Commission, like similar bodies in other countries, have found one of their main difficulties in the decision as to a standard for effluents, but the consideration was imperative, since it was absolutely implied in the warrant for their appointment, put shortly in the title of each issue, "to inquire and report what methods of treating and disposing of sewage could properly be adopted"; and this could not be decided unless the product could be judged.

In their earlier publications the Commissioners had dealt with the substantial portion of their work, on treatment and disposal, by describing very impartially the current processes (complicated by a number of patents), and detailing their observations on them at various places. They had avoided the judicial aspect which had been awaited for guidance, by adopting the uncontentious and commonsense view that most of the methods had some special merit of their own, and the choice depended on local circumstances. The effect was that each practical worker was really left to his own opinion, helped greatly, it is true, by the mass of valuable information in the Reports, but a rather disappointing outcome of the long inquiry. Administrative bodies derived little assistance towards their selection of methods, or their security against annoyance, unless they were provided with authoritative standards of results. Probably influenced by comments, and by the difficulties of the matter, the Commissioners have left this important feature to the last.

At the Royal Sanitary Institute, in February, 1913, shortly after the issue of the official Eighth Report (Vol. I.) I read a paper on it, remarking: "It would seem that according to paragraph 12 the Commissioners consider that their main objective is primarily the improvement of rivers, and only secondarily the improvement of effluents, although everyone has looked for their prescribed decision

as to the best means of purifying sewage, and also how far it was possible to recover some of the constituents for agricultural purposes." In the subsequent discussion several speakers took part who had been concerned in the inquiry, either as witnesses or investigators, including one of the Commissioners, Colonel Harding, who was in the chair. He reminded us that none of the recommendations could have legal force until embodied in an Act of Parliament, and spoke of the general approval that the proposals had met with in other countries.

The Commissioners said, in paragraph 15 of the Eighth Report: "In our view one normal standard should be fixed which would be suitable for the majority of places, and provision should be made for fixing one or two higher or lower standards to meet cases where a different standard could be justified." The general standard, as now well known, is twofold.

The first and primary requirement, based on the experience of the Fifth Report (1908), is that an effluent must not contain more than 3 parts per 100,000 of suspended solids. "Any sample which fails to pass this test should be rejected forthwith." Samples which satisfy this test must also be considered with reference to the further test of the amount of dissolved oxygen which they will absorb in five days (Eighth Report, paragraph 20). In this time it is defined that, with its suspended matters included, it must not take up more than 2.0 parts per 100,000 (2 gms. per 100,000 c.c.) of oxygen at 65° F.

At the end of their official Eighth Report of 1912 the Commissioners announced that an Appendix containing the results of investigations made by their officers would be published in a separate volume. It is now before us, and is of illuminating interest. Most of us have been naturally impatient at the length of this inquiry, but there is justification in the value of the research records which have been obtained, and these, the latest issued, are models of care and precision. Colonel Harding, in the discussion above mentioned, confessed that "his views had been considerably changed as a result of the observations made by the officers of the Royal Commission, some interesting particulars of which they would find in the Appendices about to be published. . . . The important point was brought out that if a river water did not take up more than 0.4 of oxygen under the conditions of the test there was no likelihood of any nuisance arising. . . . The statutory normal standard proposed by the Eighth Report was based on a dilution of the effluent with 8 volumes of clean river taking up 0.2 of oxygen in the 5 days test." Then from the equation (Eighth Report, paragraph 13, p. 4)—

$$\frac{x + yz}{z + 1} = 0.4$$

when x = parts of dissolved oxygen taken up by 100,000 of effluent; y = ditto taken up by river above outfall; z = dilution (proportion of river water to effluent), it follows that if y is 0.2 and z is 8, x is 2.0, and this figure is therefore adopted as the limit for an effluent. In the Fifth Report it was fixed at 1.5 for the clear liquid, but afterwards it was felt that the whole actual liquid should be considered, and the standard was raised to 2.0, allowing 0.5 for absorption by the suspended solids.

The difficulties of the Commission will be shown by the facts that:—

(1) The former limit of 1.5 for a clear liquid involved, as pointed out by myself and others, a filtration which delayed the result and altered the liquid.

(2) It is almost impossible to get a fair average sample of a turbid discharge.

The Commissioners' original objective had, of course, been an apparently simple one, to fix one standard for suspended solids and another standard for the liquid. At first this was the clear liquid, with the objection mentioned above; afterwards the whole raw effluent as collected, unfiltered, and containing the matters in suspension. Another objection has already been made to the allowance of 0.5 part for absorption of oxygen by these latter: it is considered insufficient. Mr. Ardern, of Manchester, in the debate above referred to, said that "the limits of impurity allowed by the Commissioners under these tests required a higher standard of purification than did the provisional standards at present adopted by the rivers boards in the North," which perhaps might not be a disadvantage, as the state of many of the northern rivers is by no means satisfactory; but he also said that "the proposed limit of 2.0 parts dissolved oxygen absorbed in 5 days was much more stringent than that of 1.5 parts dissolved oxygen for the effluent apart from its suspended solids, suggested by the Commissioners in their Fifth Report. Determinations of the dissolved oxygen absorption due to suspended matter showed that if an effluent contained as much as 3 parts per 100,000 of suspended matter (which it should be noted is 25 per cent. less than that at present allowed by the West Riding of Yorkshire Rivers Board), the total dissolved oxygen absorption would in most cases exceed 2.0 parts per 100,000 in 5 days at 65° F."

It is surprising that this is confirmed by the Commissioners' own evidence in the present Appendix, Vol. II. Addendum I. to section 5, p. 129, gives a comparison as regards power of taking up dissolved oxygen between (a) the liquor or effluent with the suspended solids; and (b) the same after filtration. Their results in different parts of the country agree that "sewage liquors and effluents generally, with their suspended solids, will take up twice as much dissolved oxygen, in periods up to 5 days, as the liquid portion alone will do," i.e., the suspended solids take up as much as the liquid. The Commissioners have not noticed the consequence—that if 1.5 was allowed for the filtered liquid in the Fifth Report, they ought to permit 3.0 for the unfiltered liquid in the Eighth.

The amount of dissolved oxygen that suspended matter will absorb is obviously by no means a constant, and the Commission have determined it empirically. Their 1912 suggested standard of 0.5 part oxygen for 3 parts suspended, or 16.7%, is only half the proportion indicated in this Appendix, for here if the limit of dissolved oxygen to be absorbed is 2.0, and the solids, as stated above, take up as much of the liquid, the 3 parts of solids must take up 1 part of oxygen, or 33.3% of their weight.

In the Accrington experiments (Fifth Report, Appendix IV., pp. 67 and 70), quoted on p. 80 of this Vol. II., of the Eighth Report (without, however, restating the suspended solids), the percentage of dissolved oxygen absorbed by the suspended solids, as averages of a number of analyses, is 37, 38.6, 42.5 and 46% of their weight. Therefore it is clear that the contention by Mr. Ardern and others, that the 1912 standard of 2.0 parts absorption without filtration is really more stringent than the 1908 standard of 1.5 parts after filtration, is correct.

It follows that in order to comply with the standard now proposed, and with the equation we have quoted above (which the Commissioners have taken as the basis of their suggestion), it is necessary, either that the dilution should

be greater than 10 volumes, or that the *quality* of the suspended solids should be improved. If the latter point is promoted, and the Commissioners have shown how it is quite feasible, this "Battle of the Standard" will have attained a victory over natural dangers and disadvantages which will be a more satisfactory close to their long labours than the present one.

This Appendix, Vol. II., is divided into three parts:—

Part I. gives the results of stream observations carried out by the officers of the Commission from 1909 to 1912 on a number of typical rivers at localities distributed pretty equally over England, and the figures are tabulated very clearly for reference. It is mentioned on p. 62 that a previous (unpublished) Interim Streams Report in 1910 dealt with observations on twenty-five streams, extending over nearly two years, that its provisional conclusions have been generally sustained by the later work, and that much of it, where not "superseded by the present text," is reproduced in this volume.

Part II., containing eleven sections and several addenda, examines the relative merits of various tests as correlated with riverside observations, and gives in detail the methods of carrying out the two selected tests.

Part III., "Channel Experiments," gives a description, with analyses, of the effects observed when various mixtures of sewages, effluents, and river water were made to flow through artificial open conduits 50 to 120 yards in length. The conclusions were in substantial agreement with those arising from the stream observations.

We notice that the tests selected for preference do not include a bacterial one, although, following p. 52, tables are given of bacteriological analyses carried out by Miss E. O. Hartley under Dr. Houston's direction, and comments are made such as: "Despite the high dilution, the sewage caused a serious deterioration (bacteriologically) in the quality of the river water." In fact it is said (p. 61): "The results show that sewage pollutions have a most serious *immediate* effect bacteriologically on the quality of river water," and the original state is seldom regained before fresh pollutions occur. "Even a well-oxidised sewage effluent is apt to be much more impure bacteriologically than a river water of only average purity."

No note is made as to a fish test, such as is much advocated in Germany—although it might be inferred from several observations on streams in Part I.—nor to the question of contamination of water-cress, etc. Attention is specially directed to nuisances to the nose and eye (odour, turbidity, and colour). The analytical tests chosen are those which a chemist can easily carry out and easily explain, therefore his interpretation of results can be readily understood and will be an effective weapon in the law courts. It was always difficult to make quite plain to the man in the street what "oxygen absorbed from permanganate," or "albuminoid ammonia," really meant with regard to sewage, and this led to confusion and contradiction.

Readers of this Journal will probably be most interested in the method by which dissolved oxygen is determined and its limits of accuracy. The Commissioners have adopted (p. 93) the Winkler method, as modified by Rideal and Stewart (*Analyst*, 1901, 26, 141, and Seventh Report of the Commission, Vol. II., Appendix III., p. 111), both for laboratory and field work, and have proved it to be of great accuracy. They have abandoned the Ramsay and Homfrey cuprous chloride process which I adversely criticised in the above paper (and also in *Journ. Soc.*

Chem. Ind., November 30th, 1901), and the cumbrous Adeney method, though these were the two recommended earlier by the Royal Commission.

With reference to the prescription that the samples are to be kept at 65° F. during the five days, this is somewhat higher than has usually been adopted as an average. Since the rate of absorption of oxygen by the impurities is usually much accelerated by warmth, it is necessary to work with a uniform standard, and this one has been chosen as convenient. It would be an advantage if one temperature could be agreed on internationally, so that we could all more exactly compare the experiences. In America, where this method of examination has proved of very great value, the temperature has been generally fixed at 20° C. = 68° F., and observations are also taken at 37° C., as they are more quickly obtained. Earle B. Phelps ("Bio-Chemistry of Sewage," International Congress of Applied Chemistry, New York, 1912, p. 256) finds the velocity of absorption of dissolved oxygen to be doubled between 20° and 37° C., and says that the latter temperature may be used where quick results are required, but since in this case the bacteria at work are not those ordinarily working in the stream, the 20° temperature should be used in important investigations. It must be remembered that the Royal Commissioners' present standard has a very great practical objection in its delay of five days. On this point I must further refer to my above-mentioned paper at the Royal Sanitary Institute.

Pages 63 *et seq.* of this Vol. II. detail the chemical changes occurring in rivers after discharges. The course of these (p. iii) was traced by adding to the sewage 2 to 8 ozs. of fluorescein, dissolved in dilute alkali, and following the green-coloured water down stream, watching the process of mixture. A record is given of the changes in ammonias, nitrates and chlorides in river waters and in the discharged liquids by the life action of aquatic plants. I do not think it has been before sufficiently realised that chlorides are fixed by plants in natural waters. It is said here, on p. 89: "Both chlorine and nitrate are taken up by algae and aquatic plants; this will tend to reduce further both of these constituents"; but "more samples show a reduction in chlorine than in nitric nitrogen, and the average percentage reduction in chlorine is greater than the average percentage reduction in nitric nitrogen."

It will be well to recall some elementary considerations with regard to "plankton"—the living inhabitants of natural waters. Both plants and animals contain chlorides in their structure, and it is a pity that the analyses of water plants given in section 7 did not include this figure. Aquatic plankton mainly derives its chlorides from the water, therefore lowers the quantity in the liquid. The effect obviously depends on the luxuriance of the growths, and has a connection with the variations recorded in this Appendix. The influence must be borne in mind, since differences may be due to this cause, and not to errors of sampling or analysis, or reckoned to measure dilution.

The incubator test, as judged by smell, is found (p. 202), "not sufficiently refined to distinguish between liquors which may produce doubtful, poor, and sometimes bad conditions." On p. 84 it is stated to be rather less stringent than a standard of 2.0 dissolved oxygen absorption in five days. "It might, however, come in usefully as a subsidiary standard in certain cases." We know that, especially in conjunction with methylene blue, it has been worked with success by a number of chemists, notably Scudder,

Spitta and Phelps. I see that at the American Public Health Association Meeting at Colorado Springs this month Lederer of Chicago is drawing attention to "A Serious Fallacy of the Standard Methylene Blue Putrescibility Test."

Suspended solids are now standardised by the Gooch crucible method with asbestos, and the details are minutely described at p. 103.

There are many other points inviting comment if space would allow. In conclusion, now we have such a mass of knowledge collected with such great care and rationalised so luminously, let us all be agreed in all parts of the world to work these simple standards for the purification of sewage and the improvement of natural waters, so that the results shall be comparable and the best that can be attained.

AGRICULTURAL CHEMISTRY AT THE BRITISH ASSOCIATION.

By C. T. GIMINGHAM, F.I.C.

THE programme arranged in the Agricultural Section of the British Association this year covered a wide range of subjects of great interest, and at every meeting the large lecture-room was crowded. It was unfortunate that time did not permit of adequate discussion of the majority of the papers.

On the first day, Professor T. B. Wood, in his Presidential Address reviewed some of the results of the last twenty years of agricultural research. Discussing, first, practical field trials, he emphasised strongly the need for greater care in such experiments in order to obtain really reliable results. When attempting to compare the yield per unit area on any two plots, there is inevitably a large probable error which can only be diminished by increasing the number of plots. Where the difference in yield between two plots is very large—from 50 to 100%—the single-plot method has given results of the greatest value; but if differences of the order of 10% are to be measured (and this is well worth doing) considerably more trouble must be taken to ensure accuracy.

Turning to scientific investigation, he referred to the great development of our knowledge of the processes concerned in the fertility of the soil as one of the features of recent agricultural research. The work of Russell and Hutchinson and their colleagues at Rothamsted on the partial sterilisation of soils is clearing up many outstanding problems and is finding direct practical application. Biffens' wheat-breeding experiments, which have resulted in the production of a variety of wheat of good cropping power and practically immune to the destructive disease known as yellow rust, form another case of the direct value of scientific work to the farmer. Finally, Professor Wood summarised the new ideas which have been introduced in recent work on the subject of animal nutrition.

"The Value conferred on Dung by Cake-Feeding" was considered by Mr. A. D. Hall. It is of great economic importance to know whether the gain in the manurial value of the dung, obtained by feeding large quantities of concentrated food (*e.g.*, linseed cake) is really worth the extra expenditure. It was found that the manure made by bullocks feeding on a rotation, including cake, does contain more nitrogen than the manure made by bullocks fed on hay and roots; but the difference lies

almost entirely in the soluble and volatile nitrogen, whilst there is little difference in the amount of insoluble and slowly available nitrogen. The two kinds of dung have been tested at Rothamsted with the result that, in the first season, the cake-fed dung is found to be markedly superior; but, in the following season (no more manure being added) the superiority over the hay and root dung is only very slight; and after that the two are level. The residual effect of the hay and root dung is quite as great as that of the cake-fed dung, the gain from the latter being almost entirely confined to the year of application.

Readily available nitrogen can, if necessary, be supplied as artificial manure at any time, and probably in most cases the cheaper made dung pays best, especially when it is remembered that in the ordinary making of farmyard manure the soluble nitrogen, being mostly in the form of urea, is rapidly transformed into ammonia, and suffers a loss of about 50% by volatilisation.

On Thursday, Professor Barker and the writer gave an account of their further experiments on the fungicidal action of Bordeaux Mixture. The results go to confirm their view that in practice the fungus cell kills itself by dissolving and absorbing copper when it comes into contact with or within a limited radius of particles of the copper compound which is sprayed on to the surface of the leaf. Many types of cells, such as the root hairs of seedlings, the cuticle of apple leaves, etc., have been experimented with in addition to fungus cells; and the extent of the injurious action of the copper compound is found to depend on the character of the cell wall.

On Tuesday several papers were read on subjects connected with soil fertility. Dr. Hutchinson and Mr. MacLennan gave details of their work on "The Partial Sterilisation of the Soil by means of Caustic Lime." Quicklime when mixed with soil in sufficient quantity has a partial sterilisation effect, the numbers of bacteria multiplying rapidly after an incubation period with a corresponding increase in the amount of available plant food.

At the same time, the lime has a direct chemical action, breaking down some of the more complex soil constituents. Field experiments on the comparative action of caustic lime and chalk are needed in order to obtain information on these and kindred questions from the practical point of view.

The writer gave the results of some experiments on nitrification in pasture soils containing large amounts of organic matter and, apparently, acid in reaction. When ammonium sulphate or peptone is added to such soils, most of the nitrogen is rapidly converted into nitrates, in the latter case nitrification setting in almost at once.

Part of the ammonia formed on decomposition of the peptone probably acts as the necessary base for the nitrification of the rest; or the base may be supplied by the salts of organic acids. These observations are an addition to the evidence which is accumulating, that nitrification can take place under conditions previously thought to prevent the action of the nitrifying bacteria.

Professor Bottomley discussed his experiments on "The Effect of Soluble Humates on Nitrogen Fixation and Plant Growth." He has treated peat with certain aerobic soil bacteria in such a way that the insoluble "humic acid" is mostly converted into soluble ammonium "humate." This prepared material is inoculated with nitrogen-fixing organisms and added to the soil, resulting, it is claimed, in considerable fixation of nitrogen and increase in plant growth.

THE ROTHAMSTED EXPERIMENTAL STATION, HARPENDEN.

By E. J. RUSSELL, D.Sc. (LOND.), DIRECTOR.

THE history of the Rothamsted Experimental Station affords one of the best instances of our time of individual enterprise in scientific work. In 1834 Mr. J. B. Lawes came into possession of his ancestral estate at Rothamsted; he was a very young man, with a marked taste for experimenting and a definite desire to improve the system of agriculture that he

In 1843 Lawes secured the co-operation of J. H. Gilbert, and the foundation of the Rothamsted Experimental Station dates from that event. An old barn was converted into a laboratory, and field experiments were laid out in Broadbalk wheat field and in Barnfield. As time went on the work increased so much that, in 1855, a larger and better



OLD LABORATORY TO THE LEFT; MASON LABORATORY IN THE CENTRE, AND NEW WING TO THE RIGHT.

found. Among his early attempts was a series of pot experiments which showed the remarkable effect of soluble phosphates on plant growth; these led to field trials, and these in turn to the manufacture of superphosphate on a large scale. From thenceforward Lawes' activities were divided in two sharply distinct directions: the scientific study of the plant and the soil, and the development of the artificial fertilisers industry. The only connection between the two lines of work was that some of the funds derived from the factory went to support and finally to endow the scientific laboratory.

laboratory was put up by public subscription, and more fields were taken over for experiments till, finally, six were retained exclusively for this purpose. Lawes and Gilbert worked together for fifty-seven years, and the results of their labours have been woven into the history of science and the traditions of farming. In order that the work should continue after his death Lawes, in 1899, created the Lawes Agricultural Trust, endowing it with stock to the value of £100,000, the laboratory and the lease of the land on which the experimental plots are situated. He entrusted the management to a com-

mittee composed of four members nominated by the Royal Society, two by the Royal Agricultural Society, one each by the Chemical and Linnean Societies, and the owner of Rothamsted.

A new chapter in the history of Rothamsted

also gave generous assistance to the new undertaking. Then the Society for Extending the Rothamsted Experiments was started, its object being to collect donations and annual subscriptions for the purpose of the new experiments.

For sixty-eight years the Rothamsted experiments were conducted without Government help, but in 1911 the Board of Agriculture recognised Rothamsted as the institute for dealing with soil and plant-nutrition problems. An annual grant of £2,500 was made out of the Development Fund, and a capital grant of £3,100 was given for the purpose of extension, while an equal amount was raised by the society for the purpose of taking over and stocking of the new farm of 230 acres.

The increased work of the laboratory necessitated increased accommodation, and two years ago a considerable extension was undertaken. The new wing was opened on June 27th, 1913, by the Right Hon. Walter Runciman, President of the Board of Agriculture. It was built from the designs of Messrs. Freeman and Hodgson, and consists of a large soil laboratory and director's room on the ground floor, a botanical laboratory, chemical laboratory, library and women's sitting-room on the first floor, and a glass house for water cultures on the roof. Special rooms are provided in the basement for polarimeter work and for soil incubations. The laboratory is served throughout with electrical current, which is generated in an adjoining dynamo and battery



THE FIRST ROTHAMSTED LABORATORY, 1843-55. (THIS HAD BEEN AN OLD BARN BUT WAS FITTED UP AS A LABORATORY.)

opened in 1902, when Mr. A. D. Hall was appointed director. During the progress of the older experiments great advances had been made in chemistry, botany, bacteriology and other subjects that lie at the foundation of agricultural science. This new knowledge had to be carefully examined to see what light it could throw on agricultural problems. And whilst the agricultural investigator was thus put into possession of new means for attacking old problems, the need for new work became more emphasised. For some years past economic causes had compelled the farmer to reconsider his methods, to effect economies in management, and to raise larger crops at reduced cost. But so good was the practice of the best farmers that no marked advance could be hoped for until an adequate knowledge was obtained of what the soil really is and how the plant grows there.

The first move in this direction was made possible by Mr. J. F. Mason, M.P., who, in 1906, presented the committee with the "James Mason" Bacteriological Laboratory, together with a grant towards its maintenance. In the following year the Goldsmiths' Company made a grant of £10,000 for soil investigations, which enabled an entirely new line of work to be started. The Permanent Nitrate Committee gave £2,000; the Clothworkers' Company, Dr. Hugo Müller, and other gentlemen



POT CULTURE HOUSE AT ROTHAMSTED.

house. The special work carried out in the new wing includes the investigation of the partial sterilisation of the soil, the losses of nitrogen in high farming, the biological conditions in the soil, the

composition of green crops (with particular reference at present to the sugars and starches), the effect of poisons on plants, and the distribution of weeds.

Before it was finished the new wing was already completely filled with workers, and once more the question of laboratory accommodation has come up for consideration. The old buildings are not only totally inadequate, but they have revealed certain structural defects which prevent them from being adapted to modern requirements; it has been decided, therefore, to replace them with a building similar to the new wing, but providing sufficient

is assisted by Messrs. Daish and Sawyer; while Dr. Winifred E. Brencley, assisted by Miss Adam, carries out the botanical work. In the soil laboratory Mr. E. Horton is studying the complex mixture vaguely known as humus, Mr. B. A. Keen is investigating important physical properties of the soil, and Mr. A. Appleyard is working at the loss of nitrogen that accompanies the necessary decomposition processes in the soil. Mr. Lewin picks out and studies the soil protozoa; he is succeeding Mr. Goodey, who has accepted a post at Birmingham. Mr. J. Prescott is carrying out an investigation on



INTERIOR OF THE LARGE LABORATORY IN 1855.

accommodation to allow of reasonable expansion for some years to come. The cost is estimated at about £10,000, half of which is to be raised by public subscription, while the other half will, it is expected, be obtained as a grant. The centenary of the birth of Sir John Lawes falls in 1914, and that of Sir Henry Gilbert in 1917; the occasion is, therefore, singularly opportune for erecting the laboratory as an adequate centenary memorial.

The staff at present numbers thirty members all told. Dr. Miller is in charge of the rain and drainage investigations, and Dr. Hutchinson of the Mason bacteriological laboratory, where Messrs. McLennan and Clayton are also working. Mr. W. A. Davis has charge of the work on the composition of crops, and

the phosphates of the soil, and Mr. W. Buddin is continuing the partial sterilisation work that has been going on here for some time. In addition, facilities are given for post-graduate workers who wish to investigate some of the numerous fascinating problems connected with the growth of the living plant, and especially those that can only be attacked on the spot. Chemists and botanists trained in city laboratories are often amazed to find what a wonderful thing the growing plant is, and how many simple problems connected with it await solution. No less wonderful are the problems connected with the soil. The work has the added charm that it is closely associated with great economic problems, although it is wholly scientific and not technical in the ordinary factory sense.

MOLECULAR PHYSICS.

By J. A. CROWTHER, M.A. (Fellow of St. John's College, and Demonstrator in Physics in the Cavendish Laboratory, Cambridge.)

CHAPTER VI. (*continued*).

THE CHEMISTRY OF THE MODEL ATOM.

IN the first place, it must be pointed out that all the electrons in the atom are not held in the same way. The majority of the electrons are too firmly held to be displaced by anything short of a disruption of the whole atom. A certain number, however, are held comparatively loosely. Optical experiments have shown that the number per cubic centimetre of comparatively mobile electrons which determine the dispersion of the substance is not many times greater than the number of atoms present. Similar results are obtained from a consideration of the numbers of free electrons in a metallic conductor. It will obviously be these free electrons that determine the valency of the atom. It seems very probable that the greatest number of these that any atom can gain or lose does not exceed eight, and it may be noted that this is the greatest charge ever found to be carried by a positive particle.

Since valency is a property of the simplest atoms, it seems probable that the valency electrons form the innermost ring of the atomic system. Let us suppose, now, that the maximum number of electrons which can be contained in this inner shell is eight, the minimum, of course, being zero, and let us suppose, further, that there is a tendency in every atom to give this inner ring either its maximum or minimum value. An atom with an inner ring of five electrons would then either part with its five valency electrons, in which case it would have a positive charge and, consequently, a positive valency of five, or attract three more electrons from without, making up its complement to eight. In this case it would be electro-negative in character with a charge and a valency of three. It will be noted that the sum of the two valencies is equal to the maximum number of particles in the inner ring, namely, eight.

Which of these two actions would take place would depend on the nature of the atoms with which it was placed in contact. If surrounded by atoms which tended to part with electrons, it would be electro-negative, if by atoms with a strong attraction for free electrons, it would eventually give up some, or all of its five to the stronger atom and remain electro-positive with a maximum valency of five. The atom would correspond closely to such a substance as phosphorus, which forms compounds such as PH_3 , in which it shows a negative valency of three, while, with the strongly electro-negative element, chlorine, it forms compounds such as PCl_3 and PCl_5 , in which it has a maximum positive valency of five.

To compare our results with the periodic table, we must suppose the elements of Group I., lithium, sodium, etc., to possess, when in their neutral state, only one valency or free electron, which they give up with the greatest readiness. The elements of the next group should have two free electrons and a positive valency of two. At the same time, there would be the possibility of their taking in sufficient electrons to bring their total up to eight, in which case they would possess a possible maximum negative valency of six. I am not aware that any compounds have been prepared in which this valency is exercised. It might, in any case, be expected to be very feeble.

The number of valency electrons in the atom, then, increases uniformly as we pass along the series, until we reach the halogens with a total number of seven. These have a possible positive valency of seven, as they might conceivably lose the whole number they possessed. This valency is probably exercised in compounds, such as I_2O_7 . As they contain very nearly the maximum number possible, they are, however, much more likely to acquire the one necessary electron to make their total up to eight, and thus act as strongly electro-negative elements, as in the great majority of their stable compounds, *e.g.*, NaCl , we know they do. From energy considerations we should expect that the number of electrons in the inner ring would tend to that stable number to which it was nearest to begin with. Thus, elements possessing fewer free electrons than four would be electro-positive, those with more would tend to make their complement up to eight, and be electro-negative. The elements of the carbon group (Group IV.), with four valency electrons would be almost indifferently positive or negative, as we find them to be both CO_2 and CH_4 , being stable compounds. Our complete valency scheme is thus represented by Table VII., where

TABLE VII.—TABLE OF VALENCIES OF THE PERIODIC GROUPS.

Group.	I.	II.	III.	IV.	V.	VI.	VII.
Normal valency .	+ 1	+ 2	+ 3	± 4	− 3	− 2	− 1
Additional or contra-valency .	− 7	− 6	− 5		+ 5	+ 6	+ 7

the Roman numerals indicate the group in the periodic classification. It is most interesting to note that Professor Abegg, in a very illuminating paper on valency, arrived at a precisely similar scheme from purely chemical considerations. He suggested that every element had two valencies, a normal and

a contra valency, the normal being supposed to be the stronger. The positive valencies were the normal for elements of Groups I. to III., the negative for Groups V. to VII., Group IV. being indifferently plus or minus. The sum of the normal and contra valencies for any element was eight. It will be seen that this suggestion is exactly embodied in our theoretical table.

The phenomena of variable valency and valencies of different signs have no difficulties on our hypothesis. It is, in fact, exactly what we should expect. It is not necessary that the whole of the available electrons should be extracted in one step. It is evident that the work done in extracting an electron from the atom will be greater for the second than for the first, and it is quite easy to imagine circumstances under which the ionising force was sufficient to produce the expulsion of one, but not of two electrons, while under more favourable conditions, both might escape.

The inert gases of the helium group possess no valency and, hence, presumably, no free electrons. We have already remarked that the phenomenon of the dispersion of light is due to these free electrons, which are thus sometimes spoken of as dispersional electrons. It is interesting to note, in support of the hypothesis we have advanced, that the dispersion of light in helium is abnormally small, while that of the halogen gases, which, on our theory, possess the maximum number of valency electrons, is very large.

Dnides, by means of a rather abstruse and somewhat approximate calculation, has deduced from these considerations the number of free electrons in the atoms of different elements. Some of the results are given in Table VIII. Remembering that the number of electrons in the atom must be an integer, and that the calculations are only approximate, his calculated values seem to fully bear out the assumption we have made above.

TABLE VIII.—NUMBER OF FREE ELECTRONS IN THE ATOM DEDUCED FROM THE DISPERSION OF LIGHT.

Substance.	Calculated Number of Free Electrons.	Number Assumed (maximum positive value as).
Hydrogen	1.4	1
Calcium	1.5	2
Carbon	3.7	4
Silicon	3.9	4
Oxygen	4.4	6
Chlorine	6.2	7

Again, our hypothesis explains directly the curious connection between the sign of the valency and electrical conductivity. With the exception of hydrogen, every electro-positive element conducts electricity when in the solid state. This fact is such a commonplace, that an explanation, perhaps, at first sight, hardly seems necessary. On any other theory of valency, however, it would be difficult to account for this invariable co-existence. On the

assumption, however, that electro-positive elements are those which easily give up electrons, it is evident that since these electrons will be free to move under the electric field, these elements will be able to conduct electricity, while, since the electro-negative elements tend to absorb electrons, there will be few electrons present in them in a free state, and since the atoms themselves are not able to move through the solid, the current will find no carriers, and so will be unable to pass.

One further direct deduction from our hypothesis is of interest. It can be shown that when two atoms of different sizes come into contact, the attraction of the smaller atom for the electrons contained in the larger exceeds that of the larger atom for the electrons in the smaller. There is thus a resultant force tending to drive the electrons from the larger to the smaller atom. It has been shown that in the simplest possible case an electron will actually pass between two similar atoms if the radius of the smaller is less than seven-tenths that of the larger.

Thus, among atoms of the same type, those with a smaller volume will tend to acquire, those with a larger volume will tend to lose, electrons. In the same group, therefore, the elements of greater atomic volume will be more electro-positive (or less electro-negative, as the case may be) than the elements with the smaller atomic volume. In any one group of elements the atomic volume increases with the atomic weight. Hence, we arrive at the general result, that the electro-positiveness of the elements in any group increases with increasing atomic weight. This relation has often been pointed out. A very striking example of it is seen in Group V. of the periodic classification, where the lightest element, nitrogen, is usually electro-negative, while the heaviest, bismuth, is generally electro-positive.

We have now traced out some of the consequences of the hypothesis that valency is determined by the number of loosely bound or valency electrons contained in the atom, these electrons being identical with those which determine the dispersion of light. We have also made the additional assumption that the maximum number of such electrons which can be contained in any atom is eight, and that in every case there is a tendency to make this number either eight (negative valency), or zero (positive valency).

This latter hypothesis has, it must be confessed, somewhat of an *a posteriori* air about it, and it may be interesting to investigate, briefly, whether there is any property of electron grouping from which this apparently arbitrary assumption can be deduced.

Qualitatively, at least, we can show that some such quality is a direct consequence of the laws of electron groupings which we have formulated above. It was shown that for any ring or shell of electrons to persist, there must be contained within it a certain definite number, at least, of other electrons.

Let us suppose now, that for an outer ring of A electrons this number is *a*, while for a ring of *A + 1*

electrons it is b . Consider an atom with a ring of A electrons having n other electrons within it where n is some number greater than a , but less than b . By suitable means we may extract from this atom a number of electrons equal to $n-a$, without destroying the equilibrium of the outer ring A . If, however, we succeeded in extracting one further electron, the system would become unstable and the atom would collapse.

Now we know that any real atom is a very stable structure indeed. Certain atoms, it is true, owing to circumstances we shall have to consider later, spontaneously break up into simpler substances, but there is no known agency by which we can bring about the dissolution of an atom of ordinary matter. The phenomena of radio-activity have furnished us with the clue to our failure: the energy required is too great. On the other hand, the energy required to extract single electrons from a neutral atom has been determined, experimentally, and is triflingly small. A single α -particle, for example, has sufficient energy to produce many thousands of ions. Thus, the work, required to reduce the number of electrons in the atom below the critical value a would be out of all proportion greater than that necessary to extract the electrons above this number. In effect, the value a would be a barrier which we could not overstep.

Similarly, we could add to the atom sufficient electrons to make its number up to b , without bringing about any change in atomic structure. Beyond that point, a further electron would necessitate an outer ring of $A + 1$ electrons, with a rearrangement of the atomic structure.

Thus, the two critical values a and b constitute, as it were, barriers which we cannot pass. We may extract $n - a$ electrons, at most, giving the element a positive valency of $n - a$, or we may add $b - n$ electrons, giving the atom a negative charge and negative valency of this amount. More than this we cannot achieve. The sum of these two valencies is obviously $b - a$, which is a constant for all elements with a ring of A electrons.

We have presented the argument in general terms, rather than from a consideration of the model scheme in Table V., because we did not wish to suggest that it depended in any way upon the numerous simplifications and approximations which were necessary in calculating that table. This granted, however, a concrete example taken from that table may serve to make the argument more clear.

Consider the elements with an outer ring of seventeen. We have lettered them from l to s . The number of electrons within the ring in element m is twenty-six, which is one more than is absolutely necessary for the stability of the ring. Thus, the element m might lose one, and only one electron without any violent rearrangement of the system taking place. Moreover, as the system is not much more than stable, the forces retaining the electron within the atom are not very strong, and this electron would be very easily displaced. The element m would thus be monovalent and strongly

electro-positive. The next element, n , could lose a total of two electrons without derangement of the system. It would thus be divalent and electro-positive, but as it would naturally be more stable than m , its activity would be less marked. Thus, as we pass along the series, the positive valency increases numerically, while at the same time, it decreases in intensity.

At the other end of the series the element r could take in one extra electron without raising its total number sufficiently to necessitate an outer ring

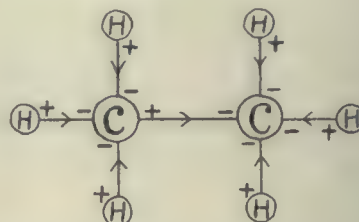


FIG. 22.—STRUCTURE OF ETHANE.

of eighteen. It would thus be monovalent and electro-negative. Theoretically, it might also lose six electrons and be hexavalent and electro-positive. From energy considerations, however, this would only occur in exceptional circumstances. Similarly, the element q preceding it would be divalent and electro-negative, though less actively so than r . Thus, our series of model atoms gives us a valency system very similar to that already described.

In conclusion, it may be noted that the electron theory of valency, while more fundamental and complete, has yet a very close resemblance to the "bond" theory, and is thus capable of including in itself all the very important and interesting results

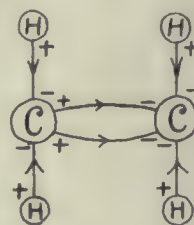


FIG. 23.—STRUCTURE OF ETHYLENE.

which have been achieved on that hypothesis. For, consider an electro-positive atom which has lost one electron. It will be the starting point of a Faraday tube of force, which, when a compound is finally formed, will end up upon the extra electron contained in the electro-negative partner of the combination. Similarly, a divalent atom would be the starting point of two such tubes, and would require two monovalent or one divalent atom for its saturation. Thus, we may say that the chemical bonds represent the Faraday tubes linking up the different atoms in the molecule.

There is this difference, however, between the two theories, that while a bond was not usually regarded as implying direction, a Faraday tube is

essentially different at its two ends, and implies a finite difference of potential. Take, now, the case of ethane, C_2H_6 . Regarding all the hydrogen atoms as positive, three Faraday tubes have their negative ends upon each of the carbon atoms (Fig. 22). If the bond between the carbon atoms is a Faraday tube it must run from one atom to the other. The atom on which it starts will then have a total negative charge of $2 \cdot e$, while the other has a total charge of $4 \cdot e$. The two carbon atoms are thus not in precisely the same electrical state.

No change in properties has yet been observed, attributable to this difference. In the case of ethylene, however (Fig. 23), where the difference between the atoms is more marked, one carrying a charge of $4 \cdot e$, while the other is electrically neutral, such differences have been noted. Take, for example, the property of the refraction of light. It has been found that the refraction produced per molecule by many organic compounds can be calculated by assigning certain definite values to the atoms of carbon, hydrogen, and the rest, the molecular refraction of any compound being then equal to the sum of the values for all the separate atoms which go to make up its molecule. It has

been found, however, that if the carbon atom is present in the ethylene linking, a certain additional amount must be added in for every atom so linked up. Thus, the atomic refraction of the carbon atom is apparently not the same in its neutral as in its charged state. A precisely similar result is obtained if we consider other additive properties, such as molecular volume. Thus, there seems to be a distinct difference in the properties of the carbon atom in these two electrical conditions.

We have developed this subject of valency at considerable length, because it is one of the most fundamental, and, at the same time, has been one of the most mysterious of all atomic properties. While it would be idle to pretend that the hypothesis which we have advanced, which is due, in the main, to Professor Sir J. J. Thomson, is at present entirely adequate to include the whole of these puzzling phenomena, it does, on the whole, correlate so successfully the more fundamental facts of valency that we cannot but feel that, at any rate, we are working along right lines and may look with some confidence to a complete solution in the perhaps not very distant future.

(To be continued.)

FRUITS OF RHODESIA.

By LOUDON M. DOUGLAS, F.R.S.E.

AMONGST the great developments which are taking place in Rhodesia, none are attracting greater attention than that of fruit growing, and within recent years it has been shown that many exotic fruits can, with the greatest advantage, be grown throughout large tracts of that country. This is not to be wondered at when it is remembered that Rhodesia is entirely within the tropics, which extend to the 23rd degree of latitude on either side of the equator, and that, generally speaking, it is in this area, around the world, that a uniformly high temperature prevails, the mean annual figures being reckoned at from 73° — 82° F.

If such conditions of temperature were permanent, and the soil uniform in texture, Rhodesia, from the fruit grower's point of view, would be a veritable Eldorado. As it is, there is very little doubt that it possesses huge potentialities in the production of exotic fruits. The prevailing temperatures vary considerably throughout the whole of Rhodesia, and, at night especially, in certain districts, the temperature sometimes falls to a very low degree. The average minimum, however, is 55° F., the average maximum being 77° F., and these conditions are unquestionably suitable for a great variety of fruits.

From the climatic point of view it may be said that the conditions in Rhodesia are unique, as the period when fruits ripen is during the long spell of dry weather, which extends from April to October, a period which coincides with great scarcity of fruits, particularly of the citrus order, in Europe.

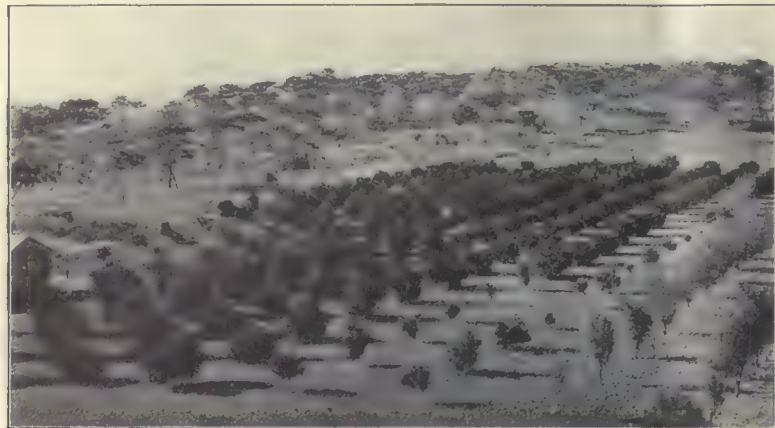
During the other months of the year heavy rain falls in many parts of the country, but the long period of sunshine referred to is of the greatest value



MEDITERRANEAN SWEET ORANGE IN ORANGE GROVE, NEAR SALISBURY, RHODESIA.

to the fruit grower, as the temperature gradually increases from the end of the rainy season. This condition suits the majority of exotic fruits, inas-

much as, while they flower at a comparatively low temperature, a higher temperature is necessary for the ripening process, and the effect of the sun's rays is then invaluable.



VIEW OF AN ORANGE GROVE, NEAR SALISBURY, RHODESIA.

FRUIT-GROWING SOILS.

The first consideration in a fruit-growing country is the condition of the soils, and in a vast territory like Rhodesia, there are many varying conditions. There are three main kinds of soil available and designated respectively, the dark or humid soil which is found in the Vleis, and the red, and granite soils.

For fruit growing the dark, humid soil is not always suitable, as frequently its very richness militates against the production of fruit, and curious as it may seem, the granite, or poorest soil of all, appears to offer the best medium for the purpose.

Rich soil has a tendency to produce woody fibre and excess of foliage, whereas a properly balanced soil, containing the mineral ingredients necessary for forming the ash of the fruit, is essentially what fruit trees require.

Generally speaking a soil of close texture is best suited for citrus and similar fruit trees, but clay soils should be entirely avoided.

The capillarity of the soil in a country like Rhodesia is of very great importance, owing to the unequal distribution of the rainfall throughout the year, and the necessity which arises for fruit trees deriving their supply of moisture from the subsoil.

In practice it has been found that, in Rhodesian fruit-growing areas, it is desirable to break up the ground very roughly during the wet season. This enables a greater amount of moisture to be retained in the soils, and there is also a larger surface presented to the atmosphere, with the consequence that weeds grow plentifully, and when they are ultimately ploughed in, as they should be about the end of February, they form a kind of humus, which is of considerable value to the soil. At the end of the rainy season the rough surface is then smoothed out, and, at intervals, shallow cultivation takes place, so that excessive evaporation from the soils is prevented.

The fruits which, so far, have been proved to be suitable to the Rhodesian climate are:—oranges, lemons, limes, pomplemousse, naartjes, shaddocks, paw-paw, guava, loquat, quince, Japanese plums, Chinese peaches, early apricots, grapes, grenadillas, Cape gooseberry, strawberries, also mangoes, bananas and pineapples in the low country where there is freedom from frost. Apples at Inyanga on the high cold veld, do well, but pears only moderately well.

It will be understood, of course, that the cultivation of such a great variety of fruits is the result of many experiments and of much experience. The one fact emerging from the others, however, is that citrus fruit is likely to be one of the most important products in Rhodesia. Oranges, lemons, limes, pomplemousse and naartjes grow profusely, to such an extent, indeed, that in places like the Mazoe Valley, near Salisbury, there are likely, in the future, to be vast citrus groves, but the climate of Rhodesia is suitable for growing most of the tropical and sub-tropical fruits.

A large proportion of Rhodesian land is sufficiently fertile to grow the majority of fruits without



YOUNG VALENTIA (LATE) ORANGES, NEAR SALISBURY, RHODESIA.

added fertiliser, good cultivation alone being necessary; but it is well to bear in mind that one of the principal plant foods is nitrogen, which can be attracted to the soil by the planting of leguminous crops in the orchards.

(To be continued.)

CURRENT LEGAL TOPICS.

By WILLIAM JAGO, F.I.C., F.C.S.

ALTHOUGH over six months have now elapsed since the trial of the Patent action of *Joseph Crosfield & Sons, Ltd. v. Techno-chemical Laboratories, Ltd.*, the recently published official report of the case in *Reports of Patent Cases*, 30, 297, justifies some comment thereon in this column. Most readers will already be acquainted with the subject-matter of the action, but briefly stated, it may be mentioned that a patent was granted to Wilhelm Normann on 21st January, 1903, for a "Process for converting unsaturated fatty acids or their glycerides into saturated compounds." The process was one of hydrogenation by the treatment of these bodies with hydrogen in the presence of a finely divided metal adapted to act as a catalyser. It was alleged that the following metals might be successfully used: platinum, iron, cobalt, copper, and especially nickel. Either the fat (glyceride) or fatty acid could be exposed in a liquid condition to a current of hydrogen in the presence of the catalyst. Thus, if pure oleic acid be heated in an oil bath, after the addition of fine nickel powder obtained by reduction in hydrogen, and then a strong current of hydrogen be passed through for a sufficient length of time, the oleic acid is completely converted into stearic acid. The quantity of nickel and the temperature are said to be immaterial as they only affect the duration of the process. Commercial fatty acids may be treated in the same manner, and the yellowish fatty acids of tallow, with a melting point of from 44° to 48° C., and an iodine value of 35.1, will, by such treatment, have the melting point raised to from 56.5° to 59° C., and the iodine value reduced to 9.8. At the same time they will have become very hard.

It was further stated that all kinds of unsaturated fatty acids and their glycerides may be easily hydrogenised; also, that it was not necessary to employ pure hydrogen, as commercial gas mixtures containing hydrogen, such as water-gas, could be used.

The following were the claims:—

(1) The process for converting unsaturated fatty acids, or their glycerides, into saturated compounds, which consists in treating the said fatty bodies with hydrogen in the presence of a finely divided metal adapted to act as a catalyser, substantially as described.

(2) The herein described manufacture of saturated fatty compounds from unsaturated fatty acids, or their glycerides, by means of water-gas or similar gas mixtures.

The Plaintiffs were the owners of the Patent, and alleged that the Defendants had infringed the same. The Defendants denied infringement, and said that the Patent was, and always had been, null and void.

The nature of the case of the Plaintiffs and also

that for the defence can be sufficiently understood by reference to the judgment.

The first most interesting point in this is the statement of the learned judge's views on the functions of expert witnesses in patent and other actions. (Several times during the course of the action the judge had objected to questions on the ground that they were directed to the construction of specifications and other documents.) The learned judge went on to say: "In my judgment there is, in regard to the admissibility of evidence, no distinction between patent actions and other actions. It is not competent in any action for witnesses to express their opinion upon any of the issues, whether of law or fact, which the court or a jury has to determine." Expert evidence is permissible "for the purpose of explaining words, or terms of science or art appearing in the documents which have to be construed by the court, or to inform the court in case the import of a word or phrase differs from its popular meaning." Other points were also mentioned, after which the judge laid down the rule "in no case is it permissible to seek the opinion of a witness upon . . . the construction of any document relied upon." This is a very considerable limitation of the latitude frequently allowed to expert witnesses. Apart from any questions of law or procedure, it is an interesting point which of two courses is most generally likely to arrive at the truth. The learned judge would have the experts give all the scientific explanations necessary and then leave the judge to form his own unaided opinion as to the meaning of the document. The other course is for an expert witness on the one side, of the class to whom the document is addressed, to say what it means to him; then there being the point at issue, for a similar witness whose views coincide with those of the opposite side to give his view of the meaning. Judges agree that counsel may thus argue as to construction. Most chemists and other scientists will, however, be of opinion that the possibilities of construction opened up to the mind of a judge by the interpretation of expert witnesses, will be far wider than any that would under any other circumstances have occurred to him unaided. The few instances of actively practising counsel being themselves also scientists are specially excepted.

It having been objected that fats could not be vaporised, it was held that "Normann did not intend to indicate vaporisation as part of his process," and that on the "liquid process . . . the patent would stand." The learned judge, however, held that it would be sufficient to describe a process which is "effective with all fats and oils and all other fatty acids in combination with any finely divided metal adapted to act as a catalyser." He further stated that "proof that some fatty acid or oil could not be successfully treated by one or more of the catalysers mentioned was immaterial so long as the exception was of no commercial importance." Also the learned judge was prepared to admit substantial saturation, sufficient for technical purposes, as satisfying the statement in the specification that there is *complete* conversion. As against the patent

it was alleged that commercial water-gas was in fact inoperative. It was held that the description of the mode of carrying the invention into practice was insufficient, and that the Patent was invalid.

The learned judge dealt with the custom of patentees referring their readers to outside sources of information, and on the whole condemned it in the following terms: "It may perhaps be permissible for a patentee to say in his specification: 'For the purpose of carrying my invention into effect, I refer you to such and such a publication in which you will find all necessary directions.' I doubt if this would fulfil his obligations to the public, but, at all events, on turning to the publication indicated you must find in clear and precise terms the very process which he claims, or one which, without further experiment, can be applied for the carrying into effect of his invention. To turn the hypothetical chemist loose into the labyrinth of long chemical papers dealing with a variety of subjects more or less connected with the matter in hand, and tell him to search for himself and adopt for the purposes of the invention what he deems applicable, would be to fall altogether short of his duty as patentee." It would seem almost a truism, and yet how difficult it is for patentees to learn the lesson that the nature of the invention, and the method of carrying it out, must be clearly and unambiguously described in the specification. The object of this document is to put the public in full possession of the whole invention as the consideration of the letters patent; but nevertheless, so many patentees will endeavour to conceal something, even though it may imperil the whole patent. If the patentee or his agent cannot so describe the invention as to fulfil this requirement, then a tithe of the money so lavishly expended afterwards on expert evidence, would at this stage, if invested in chemical and legal guidance, make the patent secure against attack on the ground of ambiguity or insufficiency of the specification.

An interesting point arises out of the claim for water-gas. Naturally all inventors wish to claim as large an invention as possible, and sometimes forget that it is better to make sure of a small invention than to claim overmuch and then lose the whole. Hence it is that so many wide and vague claims are found in specifications. In this particular case, assuming that water-gas is efficacious, and efficacious because of its hydrogen, is any specific claim really necessary? If there is a claim for hydrogen itself, and that claim only, could anyone use a mixture of hydrogen and something else without infringing the claim for hydrogen? It is submitted that no one could. Applying this principle generally, if one claim sufficiently protects, it is well to be content with it, since the second claim while not affording further protection may, by claiming too much, invalidate the whole patent, subject possibly to the remedy of disclaimer.

In one of our contemporaries attention has been directed to the bearing which the judgment in this case has on the rights of the public. First of all one must discriminate between the effects of a judgment on a petition for revocation and an action of infringe-

ment. In the former the judgment of the court in favour of the petition is itself a revocation of the patent, and the Comptroller registers the judgment. In an infringement action a decision that the patent is invalid does not destroy it, since it is not an order for the revocation of the patent, and the patentee may possibly so amend as to remove the ground on which the patent was held to be bad. That is the situation in the present case, and since the trial of the action the parties have come to terms. The defendants have taken out a licence under the letters patent, and all proceedings are stayed. The result of this is that the patent as against the world is still valid and subsisting. It is argued that the present position injuriously affects every member of the community, and that this amounts to a miscarriage of justice. The patent was originally granted for an alleged invention toward which the general public had in no way contributed. As a result of expensive litigation between the parties their respective rights have been determined; and following on this they have composed their differences. Toward the expense of this the public has contributed nothing, and it is difficult to see where any public rights arise.

It is a rather strong proposition that "a litigant who successfully attacks the validity of a patent, whether by direct action for revocation or by way of defence to an action of infringement, is performing a public service." If one believes that the principle of granting patents is bad, then their destruction is good. But the motive underlying the whole system of patents is that they stimulate the public introduction of new manufactures within the realm, and that this is so great an advantage to the community that it is to its profit to reward the inventor by a fourteen-years monopoly. If this be correct, the subsequent destruction of the patent is by no means necessarily an advantage to the public. Of course where patents are fraudulently obtained, there is every reason why they should be revoked. But how does this work out? An inventor applies in the usual way for a patent through an agent; though he may have a meritorious invention, yet the pitfalls of patent law are so numerous that he may very easily drop into one of them, and thus invalidate his patent. One need not have a long acquaintance with patent procedure to know of many instances of inventors who have thus lost the fruits of their labour and genius through no fault of their own, but owing to the existence of some obscure defect which nobody thought of when the specification was being prepared. To take an example, a chemist has invented and worked out in the laboratory a new manufacturing process. In patenting this, he applies his directions for the production of pounds of the new material to the manufacture of tons. In so doing, a precaution necessary in handling the much larger quantity is overlooked, and consequently some additional invention is necessary when applying the process on the large scale. On the difficulty arising, the patentee may easily remedy it, but nevertheless the patent would in an action of infringement be held invalid. If, in the public interest, a finding that a

patent is invalid should have further reaching consequences, then it would seem equitable that defects in the specification of what the court is satisfied on its merits is in fact a meritorious invention should be capable of being rectified on terms.

PERSONAL AND OTHER NOTES.

Mr. Francis William F. Arnaud, formerly analyst for the county borough of Portsmouth, has been appointed public analyst for the county of Kent.

Consequent upon the retirement of Dr. Frank Clowes as chief chemist of the chemical and gas testing department, the London County Council have approved of a scheme which provides for the rearrangement of that department, which will take effect from October 1st. Mr. J. H. Coste, now chief assistant in the department, will have the title of chemist, and be transferred to the Public Health Department, and the work of gas testing will now be carried out under the direction of the Public Control Department.

The Applied Science Department of Sheffield University will be opened by Lord Haldane on Saturday, October 25th.

A bronze statue of the late Dr. Ludwig Mond, erected by Messrs. Brunner, Mond & Co., Ltd., at Northwich, was unveiled on September 13th by Sir John Brunner.

We regret to announce the death of Professor Hugh Marshall, F.R.S., who passed away in London on September 6th in his forty-sixth year.

It is also with deep regret that we have to record the death of Dr. Julius Lewkowitsch which occurred after two days' illness in Switzerland.

The death is announced of Sir Walter Noel Hartley, F.R.S., formerly professor of chemistry at Dublin, in his sixty-eighth year.

The syllabus of classes in the Faculty of Engineering for 1913-14 at King's College, London, gives interesting particulars concerning the classes in mathematics, physics, chemistry, photography, metallurgy, and other kindred subjects. Facilities are offered in the various laboratories of the college for persons wishing to undertake research, and students who have obtained the B.Sc. degree may proceed to the D.Sc. by research work which may be carried out in the college. A special feature is the presence of student demonstrators, who must have completed with distinction the third year course of study in the subject in which they assist. The position is an honorary one, but they have time for their own studies and for pursuing ordinary research.

We have received particulars of copies of the departmental prospectuses of the Part-Time Courses held at the Manchester Municipal School of Technology. The subjects dealt with include chemistry and chemical technology, textile industries, mechanical and electrical engineering, and mathematics.

The next meeting of the Biochemical Society will be held in the Department of Chemical Pathology, St. Thomas's Hospital, London, on October 10th, at 8.30 p.m.

ENGINEERING NOTES.

By R. J. DUNDERDALE, B.A. (CAMB.), A.M.I.C.E.

High Temperature High Pressure Reactions.

Under the above heading a very interesting article on the researches of Professor Bergius and his assistant, Hugo Specht, appears in *Engineering* of August 22nd. Dr. Bergius read a paper on the above subject before the Society of Chemical Industry this spring, in London; but we gather that the above article was not written until after Dr. Bergius had published his monograph on "The Application of High Pressure in Chemical Reactions and an Imitation of the Formation of Coal."

The article in *Engineering* may be roughly made to fall under three heads: (a) the purely mechanical aspects of the construction of the pressure chamber or bomb; (b) the manufacture of hydrogen from water in the bomb; and (c) the manufacture of a coal-like material in the bomb from peat or cellulose.

It is proposed to shortly criticise the article under these three headings, and those further interested may be referred to the above monograph, published in Halle by Wilhelm Knapp.

The feature most dwelt on in the construction of the bomb is the method of making the main (and any other high pressure) joint. Difficulties have been found in the past to centre in this mechanical point, in that practically all packings are unsatisfactory, and the joint has therefore been made metal to metal. Formerly this was done by clamping down (by means of a screw or otherwise) a male into a female cone of the same taper, giving a surface contact. The surfaces, however, did not long remain true, and these cones needed to be reground for practically every separate occasion of use.

Kirchenbauer's cones were therefore adopted, and it is alleged, proved more satisfactory. Shortly, the principle in this joint is that the base of the male cone subtends an acuter angle than does the base of the female. Line contact is thus obtained, and it is claimed that on the wearing or compression of the male or female cone a new true surface nearer the base of the male cone is made use of.

As to point (b), the interest in which is almost purely chemical, the formation of the hydrogen at a high pressure and temperature is assisted in the bomb by a catalyte, generally a ferric salt and copper. Its merits from a commercial standpoint are the facts that the hydrogen has to undergo no further compression and that it is of 99.95% purity.

In (c), the manufacture of a coal-like substance, the peat or cellulose is first heated under pressure in contact with water, which prevents undue heating acceleration. The result under the most favourable circumstances is a powder of the composition C. 84; O. 10.6; H. 5.4. This powder is then very highly compressed and heated to about 340° C., and is then obtained in lumps resembling jet or cannel, and having a much lower oxygen and hydrogen content.

Unfortunately, throughout the article specific pressures are never mentioned in connection with specific temperatures.

Consulting Engineers.

Under the title "The Consulting Engineer. A Plea for his Employment" an interesting article appears in the

Times Engineering Supplement for August 20th. The opening sentence of that article sums up the present state of affairs accurately.

The gist is that, with the exception of large public and private corporations, the average manufacturer, instead of confining his attention to his own trade, which we may presume he thoroughly understands, uses no judgment in the erection and selection of plant and buildings except his own "and that of the contractors desirous of selling him their productions." The writer then gives what he avers is a true example in his experience of what may happen, and without quoting it we may say that it is nothing short of lurid.

But the writer of the present article has come across a case where a manufacturer, besides engaging an architect and builders, insisted on altering his instructions to both during the course of the work, thus causing considerable friction, inconvenience and delay.

The writer of the *Times* article then points out the uselessness of the ordinary unchecked contractor's guarantees, very truly saying they are not usually worth the paper they are written on, both on account of their legal form and the general vagueness as to the method by which any given guarantee is to be certified in practice after the plant is erected. The writer of the article then points out why this state of things has in a great measure arisen—a great many purchasers are suspicious that a consultant may be the agent of a certain set of contracting houses.

Most of the great and reputable consultants with no axe to grind are in London; most of the moderate sized and fairly prosperous works, which would most greatly benefit by sound consultation, are in the provinces.

The average provincial consultant is seldom much more than a covert agent, and the honest ones among them, sometimes very able engineers, frankly come out into the open and say: "We'll consult for nothing, if you'll buy your plant through us." Now very often no great harm accrues in these cases, but the dangers of buying under such circumstances are only too obvious. The present writer has in mind one large town where, for all he knows to the contrary, there is no other type of consultant than that just adumbrated—except in a few cases where the "consultant" is not an engineer at all, but simply a merchant. The fact is that provincial manufacturers would do well, when contemplating any serious expenditure on buildings or plant, to go straight to someone of genuine repute, and not to some local man who appears to save them money by offering his services for nothing or next door to it.

Preservation of Timber.

Timber in this country, where tropical heats and rains with their attendant swarms of bacterial and vermiform life are not common, is very rarely preserved with any particular care, except by big corporations, such as railways and harbour trusts.

But, owing to the increasing spread of the teredo and *Limnoria lignorum*, any timber which is to be exposed to the sea is now treated with considerable care.

It seems pretty certain now that, whatever the treatment is going to be made with, the actual treating must be by impregnation, for superficial coatings are no use against the pests mentioned. Their attack is deceptive, for while they make a modest entry through very minute holes which make but little show on the outside, once within they proceed to demolish the baulks in all directions. Of all the impregnating materials tar oils appear to be far the most

effective, and a very good article bearing on the subject and well illustrated is to be found in *Annalen für Gewerbe und Bauwesen*, 72, 30.

CORRESPONDENCE.

The Preparation of Nitroform: a Caution.

SIR,—IN the course of the work mentioned above an explosion took place, and the following record of the occurrence may serve as a caution to any who may subsequently require to prepare trinitromethane by the action of sodium ethylate on tetranitromethane.

About 50 gms. of tetranitromethane, prepared by Chattaway's method (the interaction of acetic anhydride and anhydrous nitric acid), were treated to obtain the sodium compound of the trinitro body. Kahlbaum's sodium ethylate was used, but no re-action took place, which was probably due to the fact that the chemical in question had been kept for a considerable time. Part of the tetranitromethane—about 30 gms.—was recovered after this treatment and purified. Fresh sodium ethylate was prepared by the usual action of sodium on alcohol under a reflux condenser. This was mixed with alcohol to the consistency of a thin paste, and small quantities added to the tetranitromethane at intervals. The temperature of the latter was kept low by the containing vessel being shaken in cold water. The re-action proceeded quite normally, fine yellow crystals of the sodium compound of nitroform separating out. On each addition of the ethylate, a small spitting noise was heard, and after shaking, the vessel was allowed to stand in the cold water for two or three minutes. After such an interval, on the addition of the small quantity of sodium ethylate paste—about 0.5 gm.—a violent explosion took place, the force of which may best be judged by the following facts:—

The report, which was of rather long duration, was heard within a radius of about half a mile. All the windows of the laboratory, which were of plate glass, were shattered. The iron water-bath, in which the water for cooling purposes was contained, was flattened out, and parts of it torn off and embedded in other benches some distance off. A tripod-stand, which was standing near, was distorted, one of the legs being twisted through 180 degs. The bench itself was destroyed, a large hole being blown in it, and a plank about 8 ft. long and 3 ins. broad, torn off. My watch chain was broken in three places, and the watch shattered. Some coppers which were in my pocket, were bent almost double, having evidently been struck by some object travelling with considerable velocity. Other projectiles were embedded in surrounding objects, one was driven through the door, whilst a Bunsen burner was shot through one of the window spaces, and was subsequently found some distance off, on the lawn outside. Of the bottles on the bench, no traces were found, save a few stoppers and pieces of glass scattered here and there over the laboratory floor.

With regard to the actual cause of the explosion no explanation can be offered. The temperature was kept low, and the re-action was, to all appearances, proceeding quite normally before the decomposition which occurred with such violence.

Yours faithfully,

ALEX. K. MACBETH.

Queens University, Belfast,
September 20th, 1913.

REVIEWS OF BOOKS.

"LIQUID STEEL: Its Manufacture and Cost." By David Carnegie, assisted by Sidney C. Gladwyn. LONGMANS, GREEN & Co., London, 1913. Pages 520 + vi, including Index. Chapters XLVII., with 10 Plates and 252 Illustrations. Price 25/- net.

THIS work is one of extreme value, for the various items of cost in the different processes of steel manufacture have been set out in detail. This in itself is a feature of considerable importance. The subject-matter is presented in no less than forty-seven chapters, and it is difficult to resist the conclusion that this is one of the most important text-books which have appeared of recent years.

A study of its pages leaves the ordinary chemist with an impression which it is difficult to convey in words. No less than 252 illustrations, 10 plates illustrating in detail many important operations, and 113 tables, help to make this volume what it is—and what it must obviously remain for some years—a text-book which no metallurgical chemist can possibly be without.

Generally speaking, the first section of this work deals with the materials used in steel manufacture. Part I. covers the crucible process in all its detail, including the manufacture of crucibles, and the use of coke and gas-firing furnaces for heating them. It includes a chapter on American practice, and one on costs and high-speed tool steels.

Part II. is devoted to the Bessemer process, and, naturally, deals with both the "acid" and "basic" methods of manufacture, and with the modern practice in 2-ton converters and smaller units; the relative costs of the same, composition of the charges, analysis and its uses. Part III. deals with the open-hearth process, both "acid" and "basic," in which the subject is treated with extraordinary care and detail. In Part IV. the modern developments in the electric process of smelting, etc., are dealt with. Part V. deals entirely with a comparison of costs, the assembling of steel works, costs, and labour costs, and this section alone justifies the publication of this work. It is not often that one meets with a text-book which justifies as high praise as may be given to this one. The student, manufacturer, and user may all turn to it with benefit. To the college student particularly it will give, as few books do, an idea what industrial work really means.

"LEATHER CHEMISTS' POCKET BOOK." Edited by H. R. Procter. E. & F. N. SPON, LTD., London. Pages 223 + xiv, including Index. Chapters XV., with 4 Illustrations. Price 5/- net.

Professor Procter's name is sufficiently well known to ensure that this pocket book will be of real value to the tannin chemist or student. It is published as an adjunct to the larger laboratory book by the same author. There are a few minor slips, such

as the statement that specific gravity is "the weight of unit volume"; also the one, "that any bottle with a mark on its (narrow) neck can be used for the purpose of its determination," might lead to confusion; but, generally speaking, the subject-matter is carefully compiled from the point of view of the tanner and his requirements, and is published in a handy form.

"THE TEXTILE FIBRES." By J. Merritt Matthews. Third Edition, Rewritten. CHAPMAN & HALL, LTD., London, 1913. Pages 630 + iv., with Index. Chapters XIX., including 141 Illustrations. Price 17/- net.

Dr. Merritt Matthews is well known in the States as a leading textile chemist, and in the third edition of this work the subject of the fibres is treated in a comprehensive manner. It is well illustrated by photo-micrographs. Following a general classification of the fibres, wool and hair and their chemical nature, is discussed in some detail. A chapter deals with shoddy and wool substitutes. Silk is treated in a satisfactory manner, and the same remark may be made about the vegetable fibres, including cotton (mercerised and plain), linen, jute, ramie, etc. A chapter deals in outline with artificial silks. It might be noticed in passing that the description of the manufacture of the Thiele product is hardly correct. The final section of the book is, perhaps, the best. It deals in detail with the analysis of textile fibres. This work is to be recommended to all those interested in the treatment or manufacture of textiles.

BOOKS, ETC., RECEIVED.

"Pyrites in Canada"; Its Occurrence, Exploitation, Dressing, and Uses, by Alfred W. G. Wilson. Department of Mines, Ottawa, 1912. Pages 202 + xi, with Appendices. Chapters VII., with 56 Illustrations and 1 Map.

"Chemical Technology and Analysis of Oils, Fats, and Waxes," by J. Lewkowitsch. Fifth Edition, entirely rewritten and enlarged. Vol. I. Macmillan & Co., Ltd., London, 1913. Pages 668 + xxii. Chapters XII., with Illustrations and numerous Tables. Price 25/- net.

"Quantitative Analysis in Practice," by John Waddell, J. & A. Churchill, London, 1913. Pages 162 + vi., with Appendices and Index. Chapters XIX. Price 4s. 6d. net.

"Practical Chemistry." Qualitative Exercises and Analytical Tables for Students, by J. Campbell Brown. Edited by G. D. Bengough. Sixth Edition. J. & A. Churchill, London, 1913. Pages 80. Price 2s. 6d. net.

"The Chemical Trade." Sir Isaac Pitman & Sons, Ltd., London. Pages 48. Price 6d. net.

"Coal-Mine Accidents in the United States, January and February, 1913," compiled by Frederick W. Horton, Bureau of Mines, Washington, U.S.A., 1913. Pages 12, with 8 Tables.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.

10564/12. E. BUCHHOLTZ. **Furnaces for Roasting, Smelting or otherwise Treating Ores.**

14871/12. E. K. SCOTT. **Nitrogen Fixation.**

The invention relates to electric furnaces for the direct fixation of nitrogen from the air in which the electrodes are shaped like those of a "horn" type lightning arrester. The applicant utilises three-phase alternating current, and, instead of having three separate single-phase furnaces, he combines the three phases in one furnace.

15592/12. J. F. WITTEMAN. **A Method of Utilising Volatile Products of Alcoholic Fermentations and Apparatus therefor.**

16855/12. J. HARGER. **Nitrogen.**

The process for making an inert gas consisting principally or entirely of nitrogen and carbon dioxide consists in passing a mixture of air and combustible gas in combining proportions, or the products of a carefully regulated combustion under high pressure over a catalytic agent, such as titaniferous bog iron ore, in order to ensure complete combustion.

17223/12. LAMPBLACK, LTD. and W. D. MENZIES. **An Improved Process and Apparatus for the Manufacture of Lampblack.**

17234/12. F. E. MATTHEWS, H. J. W. BLISS and H. M. ELDER. **Manufacture of Unsaturated Hydrocarbons.**

17235/12. W. H. PERKIN and F. E. MATTHEWS. **Manufacture of Butadiene and Homologues thereof.**

17482/12. S. SBOROWITZ. **Process of Making Artificial Stone and the Product produced thereby.**

17830/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & Co. **Coloured Caoutchouc.**

A process for the production of coloured caoutchouc consists in treating caoutchouc with organic dyes and in vulcanising after being thus coloured.

18005/12. FARBWERKE, VORMALS MEISTER, LUCIUS and BRÜNING. **Manufacture of Azo-dyestuffs Dyeing Cotton.**

18193/12. S. NITSCH. **A Process and Apparatus for the continuous Sweating of Paraffin.**

18207/12. L. A. J. M. JANSSEN. **Sterilising Apparatus with Receptacle for Water.**

18660/12. C. BUTTERS. **Improvement in the Treatment of Refractory Gold and Silver Ores.**

18998/12. R. LESSING. **Improvement in the Hydrogenation of Unsaturated Substances.**

19001/12. E. G. LEGRAND. **Manufacture of Artificial Silk.**

19002/12. F. BERGIUS. **Hydrogen.**

The invention relates to a process for the generation of hydrogen from metals or low metal oxides and water, and is characterised by the fact that the water is heated beyond the boiling point and allowed to act on metal, such as iron, or low metal oxide, such as ferrous oxide.

19003/12. F. BERGIUS. **Apparatus for the Manufacture of Hydrogen from Metals and Water.**

20952/12. GEWERKSCHAFT PIONIER. **Improved Manufacture of Briquettes from Ore or Blast Furnace Dust and Organic Binding Substances in Solution in Water.**

21491/12. W. SCOTT. **Method or Process of Assisting Fermentation and Apparatus therefor.**

22352/12. BADISCHE ANILIN UND SODA FABRIK. **Ammonia.**

Ammonia is manufactured and produced by freeing a mixture containing nitrogen and hydrogen from water and from compounds capable of forming water, and then passing the said mixture over a catalytic agent consisting principally of a metal, the oxide of which is reducible by hydrogen, while avoiding the presence of a metal, or metallic compound, which has considerable power of taking up nitrogen simultaneously with a metal, or metallic compound, which has considerable power of taking up hydrogen, and while maintaining a temperature not exceeding about 600° C.

22453/12. LEOPOLD CASELLA & Co. **Sulphide Colouring Matters.**

Sulphide colouring matters are manufactured by heating with sulphur at an elevated temperature and preferably in the presence of benzidine or a similarly acting substance, an acetylated amino carbazole.

24216/12. BADISCHE ANILIN UND SODA FABRIK. **Tanning.**

The manufacture and production of compounds adapted for use as tanning agents is effected by heating a phenol-sulphonic acid or a cresol-sulphonic acid under mild conditions.

24327/12. M. PRAGER. **Process for the Continuous Manufacture of Acetic Acid from Acetate of Lime.**

25627/12. C. D. MCCOURT and C. ELLIS. **Process and Apparatus for the Production of Mixtures of Heated Gas or Vapour and Products of Combustion.**

25259/12. BADISCHE ANILIN UND SODA FABRIK. **Ammonia.**

The purification of liquid ammonia, obtained catalytically from its elements, is effected by subjecting it to fractional distillation, preferably under pressure.

25974/12. P. L. T. HEROULT. **Pig Iron.**

In this process for making high grade pig iron from phosphorous ores, the pig iron in a liquid condition coming from the blast furnace, cupola or mixer, is treated in an electric furnace, in a non-oxidising atmosphere, with a basic slag containing a large proportion of limestone and a little oxide of iron, the temperature being kept somewhat low, just sufficient to maintain the slag in a liquid condition, and to cause it to enter into combination with the phosphorus of the bath, without sensibly modifying the carbon content.

26098/12. E. COLLETT. **New or Improved Method or Process for Drying Humid Gases or Vapours.**

26460/12. BADISCHE ANILIN UND SODA FABRIK. **Manufacture, Production and Employment of Chromium Compounds.**

27371/12. W. J. KNOX. **Gaseous Ozonides.**

The process of producing gaseous ozonides according to this invention consists in commingling the vapour of an ozonizable substance with ozone.

27676/12. FIRM OF FR. KÜTTNER. **Artificial Silk.**

In a process for the production of artificial silk from viscose in one operation, viscose is squirted into a heated solution saturated at the ordinary temperature both with sodium sulphate and sodium bisulphate; this bath effects the immediate coagulation of the viscose into xanthogenate, which is, under the influence of the bisulphate carried over with it from the bath, gradually converted into cellulose hydrate.

28208/12. K. L. F. FRIEDEMANN. **Linseed Oil.**

A process for rendering soluble the solid or semi-solid products of oxidation of linseed oil consists in treating the oxidation product with a concentrated fatty acid having a moderate or low boiling point, and in thereafter evaporating said acid wholly or partially.

29192/12. E. J. M. JANVIER. **Sewage Treatment.**

Apparatus for purifying liquid and solid waste material, such as sewage, comprises a preliminary separator or detritus tank into which the material is first admitted, from whence it passes into a septic tank in which the solid material is disintegrated and transformed, and finally passes through a sieve or strainer to a bacterial filter.

29235/12. HELSINGBORGSKA KOPPARVERKS AKTIEBOLAG. **Mechanical Roasting Furnace.**3147/12. R. W. WALLACE and E. WASSMER, London. **Nitrogen.** 7 February, 1912.

A process for producing nitrogen consists in passing a mixture of oxygen and nitrogen through a chamber containing phosphorus to cause the extraction of oxygen by the formation of anhydrides of phosphorus and subsequently separating the nitrogen from the anhydrides with which it is mixed. (6 claims.)

19146/12. J. STEYNIS. **Ozone.**

Apparatus for the manufacture of ozone comprises a number of discharge tubes, all connected in series, for the purpose of passing through them air to be ozonised, in combination with a corresponding number of cooling tubes connected in series and means for passing a cooling fluid through these tubes in a direction opposite to that of the air.

21586/12. L. SARASON. **Artificial Silk.**

Artificial filaments are manufactured by exposing a solution of alginic acid delivered through one or more fine apertures to the action of a coagulating reagent.

21865/12. THE BRITISH THOMSON-HOUSTON CO., LIMITED. **Manufacture of Boron Nitride.**22077/12. A. G. FRENCH. **Treatment of Refractory Complex Zinc Lead Ores.**22237/12. CHEMISCHE FABRIK VON HEYDEN, AKTIENGESELLSCHAFT. **Calcium Salts of Acidyl-ortho-oxybenzoic Acids.**23679/12. R. P. BEVAN. **Manufacture of Steel Sheets for use in making Tin Plates.**24009/12. P. ARGALL. **Separating Slimes from Sand.**24356/12. J. M. NEIL. **Treating Fluids, such as Water and Sewage.**26165/12. THE JOSSINGFJORD MANUFACTURING CO. A/S. **Electric Electrode Furnaces.**2408/13. A. G. DÜRON. **Improved Tower System for the Manufacture of Sulphuric Acid.**28072/12. THE FIRM CARL STILL. **Direct Recovery of Ammonia from the Products of the Destructive Distillation of Coal.**

FORTHCOMING PUBLICATIONS.

J. & A. CHURCHILL. — CHEMISTRY, INORGANIC AND ORGANIC, WITH EXPERIMENTS. By C. L. BLOXAM. 10th edition, rewritten and revised by A. G. BLOXAM, F.I.C., and S. JUDD LEWIS, D.Sc., F.I.C. PRACTICAL CHEMISTRY, QUALITATIVE EXERCISES AND ANALYTICAL TABLES FOR STUDENTS. By the late J. CAMPBELL BROWN, D.Sc., LL.D. 6th edition, edited by GUY D. BENGOUGH, M.A., D.Sc. INDUSTRIAL ORGANIC ANALYSIS. By PAUL S. ARUP. QUANTITATIVE ANALYSIS IN PRACTICE. An Introductory Course designed for Colleges and Universities. By JOHN WADDELL, D.Sc.

CONSTABLE & Co.—OUTLINES OF INDUSTRIAL CHEMISTRY. Edited by GUY D. BENGOUGH, M.A., D.Sc. CEMENT, CONCRETE, AND BRICKS. By A. B. SEARLE. WELDING AND CUTTING OF METALS. By L. A. GROTH. New edition. A MANUAL OF CEMENT TESTING. By W. A. RICHARDS, B.Sc. in M.E., and H. B. NORTH, D.Sc. THE SILICATES IN CHEMISTRY AND COMMERCE. By Drs. W. and D. ASCH. Translated by A. B. SEARLE. NATURAL ROCK ASPHALTS AND BITUMENS. Their Geology, History, Properties, and Industrial Application. By ARTHUR DANBY. SOME FUNDAMENTAL PROBLEMS OF CHEMISTRY OLD AND NEW. By E. A. LETTS, D.Sc. THE APPLICATION OF PHYSICO-CHEMICAL THEORY TO TECHNICAL PROCESSES AND MANUFACTURING METHODS. By Dr. R. KREMANN. Translated into English by H. E. POTTS, M.Sc., and edited by ALBERT MOND. A TEXT-BOOK OF THERMODYNAMICS: WITH SPECIAL REFERENCE TO CHEMISTRY. By JAMES RIDDICK PARTINGTON, M.Sc. (Vict.). THE THEORY AND PRACTICE OF MECHANICS. By S. E. SLOCUM, B.E., Ph.D.

CROSBY LOCKWOOD & SON.—CARBURATION IN THEORY AND PRACTICE. By R. W. A. BREWER, F.S.E., A.M.I.C.E. SCREW CUTTING FOR ENGINEERS. By ERNEST PULL. METAL PLATE WORK AND PROCESSES. By EDWIN G. BARRETT.

GURNEY AND JACKSON.—ORGANIC CHEMISTRY FOR STUDENTS OF MEDICINE. By JAMES WALKER, LL.D., F.R.S. A TEXT-BOOK OF QUANTITATIVE CHEMICAL ANALYSIS. By ALEXANDER CHARLES CUMMING, D.Sc., and SYDNEY ALEXANDER KAY, D.Sc. THE FIXATION OF ATMOSPHERIC NITROGEN. By JOSEPH KNOX, D.Sc.

LONGMANS, GREEN & Co.—A PROGRESS OF SCIENTIFIC CHEMISTRY IN OUR OWN TIMES, WITH BIOGRAPHICAL NOTICES. By Sir WILLIAM A. TILDEN, F.R.S. A DICTIONARY OF APPLIED CHEMISTRY. By Sir EDWARD THORPE, C.B., LL.D., F.R.S. Assisted by Eminent Contributors. Vol. V. Sodium-Z.

MACMILLAN & Co.—A TREATISE ON CHEMISTRY. By Sir H. E. ROSCOE and C. SCHORLEMMER, F.R.S. Vol. II.—The Metals. New edition.

METHUEN & Co.—GAS TESTING AND AIR MEASUREMENT: A Manual for Deputies, Miners, etc. By CHARLES CHANDLEY, M.Inst.M.E. PRACTICAL SCIENCE FOR ENGINEERING STUDENTS. By H. STANLEY, B.Sc. A THIRD-YEAR COURSE OF ORGANIC CHEMISTRY FOR TECHNICAL INSTITUTES. By T. P. HILDITCH, D.Sc. (Lond.), F.I.C.

COMMERCIAL AND TRADE REVIEW.

GENERAL NOTES.

The Curtailing of the Nitrate Production.

After protracted negotiations by the Chilean nitrate producers an agreement has been reached regarding the scheme to restrict the output for six months, and the interests combined will now proceed in curtailing the output. The aggregate production of the Chilean producers totals 60,000,000 quintals, and it depended on a combination of a minimum of 40,000,000 quintals agreeing to restrict the output before the scheme could be adopted. The agreement now reached will hold for at least six months, and 10% of the output controlled by the combination will be withheld from the market. As this will amount to 90,000 tons or 2,000,000 quintals during the next six months the supply will be reduced to about that of last year. The effect of the combine has been to keep up prices, and, following the decision at Iquique, they will probably go higher. According to opinion in well-informed circles in Liverpool, there is likely to be strong opposition to the proposed co-operation between the producers and the Chilean Government, for, though a small body of producers are in favour of working on lines of co-operation with the Government, many are opposed to any agreement of this kind. A further difficulty is anticipated on the tax point of view. There is an export duty of £2 12s. 6d. per ton on nitrate, and the Government have based their Budget on the unrestricted output of 60,000,000 quintals, but the aim of the combine is to reduce the output, and thus the Budget of the Government may suffer as the result of the curtailment.

Sea-salt as a Fertiliser.

Many farmers are convinced that sea-salt acts like poison on plant life, which opinion seems to be confirmed by the fact that many parts of the country close to the sea are barren. There are, however, certain plants which thrive very well on soil washed by the sea, and a series of experiments carried out at the Royal Agricultural Station of Magyarowar in Hungary seems to prove that a certain quantity of sea salt acts as a stimulant on the crops. The experiments were conducted with beet sugar fields, and the production of beets in consequence of the fertilisation with sea-salt was astonishing when compared with other fields in the vicinity which received no treatment with salt. The trials will be continued, although the results for the last four years were uniformly convincing.

The Progress of the Margarine Industry.

The "Annual Review of the Dairy Products Trade," issued recently by the well-known importing firm of W. Weddel & Co., contains an appendix in which the progress of the margarine industry is treated in a very interesting way. It appears that the butter trade has good reason to fear the growing competition of margarine or artificial butter, on account of the improvement which the quality of the latter has shown in recent years. The time has passed when margarine was a mixture of animal fats, such as oleo, stearine, beef tallow and others. To-day there are

three different kinds: oleo-margarine made from animal fats, vegetable margarine made from nuts, mostly cocoanuts, and a margarine made from a mixture of the two varieties.

The manufacturers have taken full advantage of the progress in chemical science, and researches into the origin of flavours, both on the bacterial and on the chemico-physical bases, have greatly increased. These studies are still going on, but the results already secured are of considerable commercial value. On the bacterial side they have utilised in their ripening and churning processes, with almost complete certainty of result, the lactic acid ferments (known in the butter factories as "starters"), and have been able thereby to give to neutral animal and vegetable fats a lactic acid flavour. On the chemico-physical side the process of hardening liquid oils by means of hydrogen has been applied to cottonseed, soya beans, sunflower, etc., and has already proved as successful as with oils used in the manufacture of soap. The process removes all flavour and colour, and at the same time solidifies the oil. Margarine manufacturers, by means of scientific research, have also been successful in purifying and neutralising the flavour of oleo and other animal fats, and have thus revolutionised the making of margarine since its first invention by Mege Mouriés.

As an illustration of the scientific control and costly machinery now in use in one of the best up-to-date margarine factories, the following account is of interest: The room for producing the butter flavour in margarine contains a number of vats filled with new milk, all of which are fermented by lactic acid bacteria. Some factories cultivate their own special variety of bacteria. To prevent any foreign ferments obtaining admission to the milk in the vats, this room is cut off from the ordinary atmosphere by being made practically airtight, and is supplied by means of suction fans with an atmosphere thoroughly washed and filtered by passing through a continuous shower of water from an artesian well, so that no dust or any foreign bacteria or germs can reach it. Everything possible to secure perfect hygienic conditions, and every invention to improve the quality of the margarine is adopted regardless of expense.

The only possibility for butter factories competing successfully with margarine is in taking advantage of all the discoveries in chemical science, studying the origin of flavours from the bacterial and chemico-physical standpoint, and following the example of the margarine manufacturer.

Synthetic Milk Production from Soya Beans in Liverpool.

A factory for the making of synthetic milk from soya beans and other ingredients is shortly to be established at Liverpool. Soya beans contain 40% of "soluble casein," under conditions which admit of its ready utilisation for the making of milk, which, as regards nutriment, is claimed to be equal to cow's milk, having a fat more easily assimilable than that of the latter. The company projecting to

establish a factory in Liverpool is the "Synthetic Milk Syndicate, Ltd.," in London, and they will work according to Dr. Fritz Gössel's process (of Stockheim, Essen, Germany). For the production of 100 litres of milk the procedure is as follows: About 10 kilos. of finely ground soya beans (or earth or pistachio nuts, or sesame or teel seeds, or mixtures of same) are mixed with about 100 litres of pure water and a small quantity (about 5 gms.) of phosphate of sodium, or potassium or the like, allowed to stand about an hour, and then slowly brought to the boiling point and only just allowed to boil, and then suitably filtered and pressed after it has been cooled to about 50° C. About 2.4 kilos. of milk sugar or other suitable carbohydrates; about 6 gms. of sodium chloride and 60 gms. of carbonate of sodium are dissolved in the liquor run off, and about 2 kilos. of sesame oil or any other suitable mixture of fats or oils, mixed with the solution. The milky liquor obtained would be brought to the volume of 100 litres by the addition of pure water. The "milk" can be manufactured at a cost which will admit of its being sold to dealers at 2d. per quart.

Contaminated Milk: Condition of the London Supply.

Dr. Collingridge, in his last report as Medical Officer of Health for the City, mentions that, in order to determine to what extent milk, on arriving in London, could be regarded as responsible for the dissemination of tuberculosis, a system of taking samples on arrival at the City railway termini, and then having them bacteriologically tested was established in 1912. Last year thirty samples were taken and tested. The results of these tests indicated the prevalence of highly unsatisfactory conditions in the milk trade, although the milk was in nearly all cases up to official standard, and free from boric acid or formalin.

In regard to the Milk and Cream Regulations issued by the Local Government Board, Dr. Collingridge notes what he regards as a serious omission, namely, the lack of any provision for the analyst's certificate being by itself considered as evidence. This error should be rectified.

Norwegian Production of Nitrates from the Air.

The Société Norvégienne de l'Azote et des Forces Hydroélectrique, Notodden, the Norwegian undertaking formed in 1905 to manufacture nitrates from the air, is paying a dividend of 8% on the preference shares, as last year, and 6% on the ordinary shares. The total capital of the company is 42.64 million kronen, and it is being increased to 72 million kronen, whilst loans to the amount of 18 million kronen are to be issued. The report states that the works and power stations of the company have worked with entire satisfaction during the year, and agreements have been made for the electrification of the remaining half of the Rjukan Falls, and the exploitation of the water power in the Tyin and Matte districts. The output of calcium nitrate last year was 80,000 tons, half of which was exported to Germany. A beginning has been made with the manufacture on a large scale of pure nitric acid for use in the production of explosives. In addition to Swedish and Norwegian capital, the French financial institution the Banque de Paris et des Pays-Bas is interested in the concern, which is the largest of the Norwegian industrial undertakings.

Fish Oil and Guano in Southern India.

A new industry has lately become established on the West Coast of Southern India for the manufacture from the

oil sardine of fish oil and guano. The industry promises to be quite profitable to the small factories scattered along the coast line. Previously, sardines in many thousands of tons had been dried whole on the beach for manure, but by this wasteful process all the oil was lost. The rapid development of this new industry is shown by the fact that while in 1909 there were but two little factories in operation, one being a Governmental experiment station, yet in the season 1910-11 there were nine small factories running, and many more being prepared or projected, and the season 1911-12 opened with no fewer than forty-five factories at Malabar and South Canara, while there was a probability of others being established in Cochin and Travancore.

M. L.

THE "THERMOFEED" REGULATOR.

By J. G. DAVIS, B.Sc. (ENG.), A.C.G.I.

IT is a matter of universal consent that, in view of the ever narrowing margin allowable for the inefficiency of

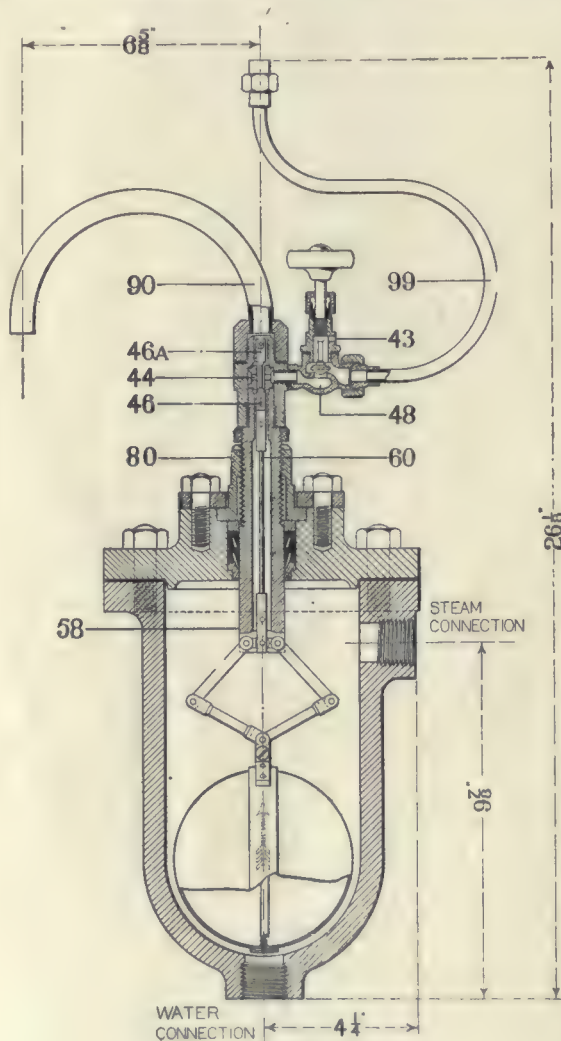


FIG. 71.

methods of energy conversion, any process or appliance which will effectively reduce the losses attendant upon fuel

combustion and steam-raising merits the earnest consideration of industrial men generally.

Subject to the condition that there is a commercial as well as a technical economy, that is to say, provided that the expenses incurred by diminishing certain losses do not exceed the saving effected by suppressing such losses, the time factor alone becomes determinant in measuring the extent of the advantage obtainable by introducing an innovation in system or plant.

Among the comparatively few means of waste reducing,

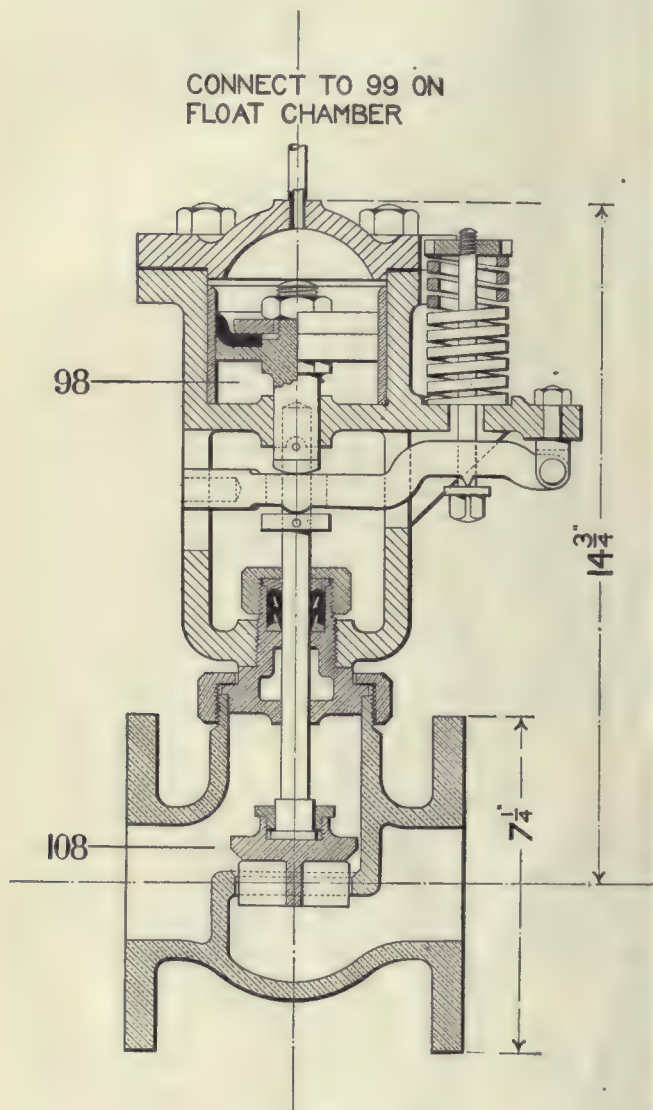


FIG. 2.

which have their place in steam-raising plant proper, the "Thermofeed" regulator must be considered as taking a prominent place, and it is surprising to note, in view of its importance economically to the steam-engineer, that the question of feed water control has been so little investigated during the past years.

The low overall efficiency of steam-raising plant has been so long accepted that little effort appears to have been made to better it, apart from the extensive work involved in the design of water tube boilers, mechanical stokers (fuel regulators), and engines and gear more nearly approaching perfection. The "Thermofeed" regulator aims at the root of a main factor of good boiler performance, namely,

the application of the exact amount of feed water necessary to supply the requirements of the heating surface in order to obtain greatest efficiency from the boiler to which the apparatus is fitted.

The fact that each individual boiler has its grate or furnace area of fixed extent, and capable of yielding a certain amount of heat with a given fuel, needs no explanation; but though water is commonly recognised as a bad conductor of heat, it is not so generally realised that, particularly in boilers of such types as the "Lancashire," the presence of an excess of water between the heated furnace shell and the evaporating surfaces has the effect of retarding circulation generally in the boiler, so reducing its steam-producing powers and efficiency.

For each boiler there is a certain feed water level, such that, if this be maintained constant, the fuel is consumed to the best advantage.

With the water below this level there is insufficient water to absorb all the heat available, an undue proportion passing to the chimney, whilst too rapid a feed prevents the maintenance of the proper rate of evaporation at the temperature prevailing, with a consequent drop in the pressure.

Forced firing may reclaim this pressure, but this at best will do no more than a lesser amount of fuel could have accomplished if the feed level had been maintained at its most economical height, and the evident net result is a direct waste of fuel.

Furthermore, the closest attention on the part of the boiler attendant is necessary in order to keep step between fuel and water feed, and maintain a constant water level, the value of which is known to be best for the boiler in question under fixed working conditions.

The "Thermofeed" is a comparatively simple piece of apparatus which when once fixed and adjusted by the attendant engineer will secure the persistence of the constant feed water level desired, without further attention, over an unlimited period.

Apart from all possible inefficiency on the part of boiler attendants, the troubles of lag and failure in the indications of gauge glasses have to be considered, and from this point of view alone an apparatus which is both automatic in its action and more sensitive to changes in the water level than ordinary boiler gauges is a welcome addition to steam power plant.

Protection of the boiler from the dangers of low water level due to insufficient feed supply, the prevention of "priming," and the protection of the engines from wet steam due to high water level, and increased efficiency of the pre-heating system due to smoother supply conditions, are among other advantages attendant upon a constant feed level.

Messrs. Ronald Trist & Co., Ltd., of London, who supply the apparatus, claim that the water level will be maintained constant by the "Thermofeed" to within $\frac{1}{8}$ in. in such boilers, and within $\frac{1}{4}$ in. in water tube boilers.

An average saving due to "Thermofeed" control of from 4.5% to 8% in the fuel normally wasted is no uncommon thing when reckoned over a considerable period, whilst the saving over short periods where undesirable feed conditions prevail amounts to over 17% occasionally.

Fig. 1 shows the general arrangement of the "Thermofeed" in sectional elevation.

Fig. 2 shows the double regulating value in section. When this is on the outer seat, cylinder 98 is placed in connection with the control valve 46, and the "Thermofeed" is in action. When on the inner seat, cylinder 98 is set

open to the atmospheric pressure *via* the ports in the circular block 44; the "Thermofeed" is then put out of action, and the automatic regulating valve is left full open. Provision is thus made for hand-variation of the working level of the water, if desired, independently of the float mechanism, by means of three-way valve 43.

The main mechanical feature of the apparatus is a single controlling valve 46 (see Fig. 1), operating between two seats, all embodied in a small part screwed on to the stem reaching from the toggle-joint in the float-chamber to the top of the vertical spindle. The float is of spun copper, hermetically sealed, and has one-tenth part of its vertical movements transmitted to valve 46.

Rise of the water level and float cause valve 46 to be pulled downwards, and permit steam to pass through the lower valve on to the piston in the cylinder 98, this gradually forcing the main regulating valve 108 down on to its seat.

The sleeve 58 (Fig. 1) is secured to all the above described controlling mechanism, and the rotation of the nut 80 allows of fine adjustment of the position of the water level whilst in action.

The ease of adjustment and of placing in and out of action by means of valve 43, while under steam, combined with general compactness and freedom from choking or corrosion of the parts, are factors of considerable importance in a device of this kind.

The apparatus, complete in itself, ensures regular and effective heating and evaporation with consequent economies in fuel; it also tends to materially reduce upkeep costs, and lengthen the life of steam-raising plant to which it is attached.

MARKET REPORT.

LONDON.—The expected revival in the chemical trade after the summer holidays has not taken place so far, and the general prospects for the future are scarcely so favourable as they were at the time of the last report. The chief reason for the altered conditions is the critical turn the labour situation has taken during the last few days. Although at present the immediate effect is only felt in the north, it may at any time extend to other parts of the country and cause a general dislocation of trade. The apprehension created by this possibility and the general feeling of insecurity is, of course, not conducive to business activity, which may explain the slackness in several important sections of the markets.

In addition to the quiet home demand, the dulness in the export trade is apt to check any undue optimism. In sympathy with other branches of the trade, the imports and exports of chemical products during August have shown a considerable decline. This excited perhaps more interest than it really deserves, as it seems to indicate an interruption of the long period of increases to which we have been accustomed. The value of the exports of chemicals, drugs, dyes, and colours amounted to £1,548,181, representing a decrease of £55,065 compared with last year.

If we survey the different sections of the market, we find that the fertiliser position has been further improved. Sulphate of ammonia has brightened up on account of better home demand and the prospect of increased shipments to the United States. The small American cotton crop resulting in a correspondingly short seed production promises to help the consumption of sulphate of ammonia for fertilising purposes. This may possibly counteract the influence of increased ammonia production at home

and abroad. Another factor exercising a beneficial influence on the product is the projected curtailment of the nitrate production in Chile, although this step may not prevent an ample supply to the world's markets. The present price for grey, 25% quality sulphate of ammonia, for prompt delivery is £13, but for forward delivery, makers ask 5s. to 7s. 6d. more. The market for tar products is very quiet, even dull. Buyers of pitch are delaying their purchases, and the production of this article is, of course, beginning to increase. In spite of this, makers are very confident that the shipping season will bring a rush demand, and that they will then be able to dictate their own terms. This accounts for their firm attitude and disinclination to meet buyers. Pitch quotations range between 45s. to 48s. per ton. The demand for benzols remains quite fair, though not expanding quite so rapidly as expected by the producers and sellers. Continental consumers are still reluctant to pay the prices asked, yet the exports of benzols are increasing very satisfactorily, and if they continue at the same rate as during the first eight months of the year, 1913 promises to show a very considerable expansion of the shipments, in addition to the increased home consumption for motor fuel purposes. The present price for 50% quality is 1s. to 1s. 1½d., and for 90% 1s. 1d. to 1s. 1½d. per gallon. There is no improvement to record in the carbolic acid section, which remains quite neglected with a downward tendency. The nominal quotation for crude 60% East Coast prompt is 1s. 3d., West Coast 1s. 2½d. to 1s. 3d. per gallon. Crystals are obtainable at 4½d. to 4¾d. per lb. Creosote maintains its steadiness, and there is no apparent sign of a coming change.

MANCHESTER.—The business life of this port has been entirely upset by the labour troubles affecting the whole surrounding district. Under the circumstances, it is very difficult to conduct business, as the uncertainty in connection with the settlement of the troubles acts as a deterrent to any activity which might have developed in the ordinary course of things. The trouble among the labourers at the Salford Docks has interrupted some sections of the trade not immediately connected with the chemical industry, but it helped to create a feeling of disquietude. The staple industry of Lancashire is threatened by a short supply of raw material, necessitating great economy in working expenses. It is even feared that short time will be adopted unless the cotton trade improves speedily. The home trade in heavy chemicals is rather quiet, which may partly be accounted for by the transport difficulties. Bleaching powder remains firm at £5 7s. 6d. to £5 12s. 6d.; caustic soda 60% is worth £8 12s. 6d., 70% £9 12s. 6d., and 77% £10 12s. 6d. Cream of tartar and citric acid favour sellers, who ask 2s. per lb. of the latter. For 95% cream of tartar buyers have to pay 93s. and for 99% to 100% quality 96s. to 97s.

LIVERPOOL.—Any improvement which might have taken place has been checked by the outbreak of fresh labour troubles. Although it is confidently expected that these will be peacefully settled immediately, they have interrupted business and delayed the expected revival. Sulphate of copper has gone higher in accordance with the rise of the metal, though hardly at the same rate as the latter. The demand has improved a little, but leaves still much to be desired. The spot quotation is £24 5d. per ton. Sulphate of ammonia tends upwards on account of better home demand. The price for prompt delivery f.o.r. is now £13 11s. 3d. to £13 12s. 6d. per ton. Cream of tartar has experienced an improved inquiry, intensifying the existent scarcity. 98% quality is firmly held at 93s.,

and 92% at 89s. per cwt. Arsenic shows some weakness, although some fair transactions have taken place at £13 10s. per ton.

GLASGOW.—Between 400 and 500 men at the chemical works of Messrs. John and James White & Co., Shawfield Works, Rutherglen, are on strike. The reason is the refusal of the firm to grant increased wages to furnacemen and labourers. The employers refuse to negotiate with the men's trade representatives, who are now endeavouring to cause the other workmen to join the movement.

FINANCIAL NOTES.

THE announcement is made that in conjunction with the soap and chemical consolidation scheme the capital of Messrs. Joseph Crosfield & Sons, Ltd., is to be increased. The pre-preference and preference £10 shares are being subdivided into £1 shares, and it is intimated that 250,000 £1 6% cumulative preference shares at 21s. each will be issued immediately, but will be confined to existing shareholders in Crosfields, Ltd., Brunner Mond & Co., and to the customers of Crosfields. Messrs. Brunner Mond own all Crosfield ordinary shares, and intend to take all the shares of the new issue not otherwise applied for. Messrs. Crosfield's shareholders are authorising the increase of nominal capital to £1,300,000, of which 400,000 pre-preference and 300,000 ordinary shares have been issued. The 250,000 cumulative preference shares mentioned are part of an issue of 500,000.

The Dominion Chemical and Lumber Co., Ltd., states that the company is making favourable progress in manufacturing and distributing wood chemicals, charcoal, and acetate of lime, and that the directors are pursuing a vigorous policy, which is securing for the company a substantial share of the Canadian market.

TRADE ITEMS.

MESSRS. W. AND T. AVERY, LTD., Cowcross Street, London, E.C., send their latest catalogue of chemists' scales. The name of this firm is a guarantee of both quality and durability, and the catalogue includes an analytical balance to take 200 gms. with a sensitive of one-tenth milligram; interesting scales for rough laboratory use for weight up to 10 lbs. or above, and also types of steelyard balances to weigh up to 1 ton.

The latest circular issued by the Bonecourt Surface Combustion Co., Ltd., of Victoria Street, London, S.W., contains interesting particulars concerning the efficiency of this system of heating for coal or oil firing, and also the utilisation of waste heat. The result of tests made by the Berlin-Anhaltische Maschinenbau A-G., indicates an efficiency up to 93.3%, and shows an evaporative power of 33.9 lbs., per square foot. The catalogue is illustrated and gives further interesting particulars.

Messrs. William Gardner & Sons, Ltd., Gloucester, have sent their recently issued pamphlet No. 19, dealing with patent sifting and mixing machines. This firm exhibited their machines at the recent Bakers' and Grocers' Exhibitions, and it is stated that over 4,000 are in use by leading firms in each trade alone.

Messrs. Musgrave & Co., Ltd., Maddox Street, London, W., send a notice of their "Ulster" high pressure fan, for blowing or exhausting in connection with power gas plants, chemical manufactures, etc. The "Ulster" forge fans are claimed to be of high efficiency, and are made in eleven sizes, which give a pressure at the fan of from 4 to 9 ins. of water. The smallest size requires $\frac{1}{4}$ h.p. and the largest 40 h.p. for driving.

The British Thomson-Houston Co., Ltd., announce a further reduction in the price of Mazda lamps, which they claim to be the first lamps produced with filaments drawn from pure tungsten. With added strength and increased economy these lamps are now employed for street, tramcar, railway, motor car, and other lighting. It is claimed that an 8-c.p. Mazda lamp will burn for a hundred hours with a current consumption of one unit, and that larger lamps take current in the same proportion.

SHARE LIST.

Name of Company.	September 24th.	August 25th.
Alby United Carbide	1 $\frac{1}{4}$ 2	1 $\frac{1}{4}$ 2
Ditto. Pref.	3 $\frac{1}{2}$ 1 $\frac{1}{2}$	3 $\frac{1}{2}$ 1 $\frac{1}{2}$
Associated Portland Cement. (10)	7 $\frac{1}{8}$ 7 $\frac{1}{8}$	7 $\frac{1}{8}$ 7 $\frac{1}{8}$
Ditto. Pref. (10)	8 $\frac{1}{4}$ 9 $\frac{1}{4}$	8 $\frac{1}{4}$ 9 $\frac{1}{4}$
Babcock-Wilcox. Ord.	3 $\frac{1}{8}$ 3 $\frac{1}{8}$	3 $\frac{1}{8}$ 3 $\frac{1}{8}$
Ditto. Pref.	1 $\frac{1}{8}$ 1 $\frac{1}{8}$	1 $\frac{1}{8}$ 1 $\frac{1}{8}$
Bell's United Asbestos	1 $\frac{1}{8}$ 1 $\frac{1}{8}$	1 $\frac{1}{8}$ 1 $\frac{1}{8}$ xd
Bleachers' Association. Ord. ..	3 $\frac{1}{2}$ 3 $\frac{1}{2}$	3 $\frac{1}{2}$ 3 $\frac{1}{2}$
Ditto. Pref.	1 $\frac{1}{8}$ 1 $\frac{1}{8}$	1 $\frac{1}{8}$ 1 $\frac{1}{8}$
Borax Consolidated. Pfd. (5) ..	5 $\frac{1}{8}$ 5 $\frac{1}{8}$	5 $\frac{1}{8}$ 5 $\frac{1}{8}$
Ditto. Defd.	1 $\frac{1}{8}$ 2	1 $\frac{1}{8}$ 1 $\frac{1}{8}$
Ditto. Pref. (10)	11 11 $\frac{1}{2}$	10 $\frac{1}{2}$ 11
Bradford Dyers	1 $\frac{1}{2}$ 1 $\frac{1}{2}$	1 $\frac{1}{2}$ 1 $\frac{1}{2}$
Ditto. Pref.	1 $\frac{1}{2}$ 1 $\frac{1}{2}$	1 $\frac{1}{2}$ 1 $\frac{1}{2}$
British Oil and Cake. Ord. ..	1 $\frac{1}{8}$ 1 $\frac{1}{8}$	1 $\frac{1}{8}$ 1 $\frac{1}{8}$
Brunner Mond. Ord.	4 $\frac{1}{2}$ 4 $\frac{1}{2}$	4 $\frac{1}{2}$ 4 $\frac{1}{2}$
Ditto. 7% Pref. (10)	14 $\frac{1}{2}$ 15 $\frac{1}{2}$	14 $\frac{1}{2}$ 15 $\frac{1}{2}$
Bryant and May. Pref.	2 $\frac{1}{2}$ 2 $\frac{1}{2}$	2 $\frac{1}{2}$ 2 $\frac{1}{2}$
Calico Printers	3 $\frac{1}{2}$ 3 $\frac{1}{2}$	3 $\frac{1}{2}$ 3 $\frac{1}{2}$
Ditto. Pref.	3 $\frac{1}{2}$ 3 $\frac{1}{2}$	3 $\frac{1}{2}$ 3 $\frac{1}{2}$
Castner Kellner	3 $\frac{1}{2}$ 3 $\frac{1}{2}$	3 $\frac{1}{2}$ 3 $\frac{1}{2}$
Commercial Salt. (2/-)	7/9 8/3	7/9 8/3
Crossley & Sons. (2)	1 $\frac{1}{2}$ 2	1 $\frac{1}{2}$ 2
Ditto. 5% Pref.	4 $\frac{1}{2}$ 5	4 $\frac{1}{2}$ 4 $\frac{1}{2}$
Eastman Kodak. (\$100)	590 630xd	600 640
Eley Brothers	1 $\frac{1}{2}$ 1 $\frac{1}{2}$	1 $\frac{1}{2}$ 1 $\frac{1}{2}$
Fraser and Chalmers. (1/3) ..	1 1 $\frac{1}{2}$	1 1 $\frac{1}{2}$
Gas Light and Coke. (S.)	101 103	101 103xd
Ditto. 4% Pref. (S)	93 96	93 96xd
Greenwich Lino. (1/2)	3 $\frac{1}{2}$ 3 $\frac{1}{2}$	3 $\frac{1}{2}$ 3 $\frac{1}{2}$
Harrison and Crossfield. Pref. ..	1 $\frac{1}{8}$ 1 $\frac{1}{8}$	1 $\frac{1}{8}$ 1 $\frac{1}{8}$
Imperial Continental. (S)	163 168	162 167
Ditto. 3 $\frac{1}{2}$ % Debenture (S) ..	83 85	83 85xd
India Rubber Co. (10)	12 $\frac{1}{2}$ 13 $\frac{1}{2}$	12 $\frac{1}{2}$ 13 $\frac{1}{2}$
International Salt	8/- 9/-	7/- 8/-
Ditto. Pref. (17/6 pd.)	2 $\frac{1}{2}$ 2 $\frac{1}{2}$ pm.	1 $\frac{1}{2}$ pm. 1 $\frac{1}{2}$ pm.
Lever Brothers. 1st Pref. (10) ..	11 11 $\frac{1}{2}$	10 $\frac{1}{2}$ 11 $\frac{1}{2}$
Lister & Co. Ord.	1 $\frac{1}{8}$ 1 $\frac{1}{8}$	1 $\frac{1}{8}$ 1 $\frac{1}{8}$
Mappin & Webb. Ord.	1 $\frac{1}{8}$ 1 $\frac{1}{8}$	1 $\frac{1}{8}$ 1 $\frac{1}{8}$
Neuchâtel Asphalt. (10/-)	9 $\frac{1}{8}$ 9 $\frac{1}{8}$	9 $\frac{1}{8}$ 9 $\frac{1}{8}$
Nobel Dynamite. (10)	16 $\frac{1}{2}$ 17 $\frac{1}{2}$	16 $\frac{1}{2}$ 17 $\frac{1}{2}$
Ditto. Bearer (10)	17 17 $\frac{1}{2}$	16 $\frac{1}{2}$ 17 $\frac{1}{2}$
Ditto. 5% Pref. (10)	11 12	10 $\frac{1}{2}$ 11 $\frac{1}{2}$
Pears, A. and F. Ord.	1 $\frac{1}{8}$ 1 $\frac{1}{8}$	1 $\frac{1}{8}$ 1 $\frac{1}{8}$
Ditto. 6% Pref. (10)	12 12 $\frac{1}{2}$	11 $\frac{1}{2}$ 12 $\frac{1}{2}$
Price's Candle. (16)	35 $\frac{1}{2}$ 37 $\frac{1}{2}$ xd	35 $\frac{1}{2}$ 37 $\frac{1}{2}$
Rosario. (5)	9 $\frac{1}{8}$ 9 $\frac{1}{8}$	9 $\frac{1}{8}$ 9 $\frac{1}{8}$
Salt Union. (4)	1 $\frac{1}{8}$ 1 $\frac{1}{8}$	1 $\frac{1}{8}$ 1 $\frac{1}{8}$
South Metropolitan 4% Stan-		
dard (S)	109 111	108 110xd
Ditto. 3% Debenture (S)	73 75	72 74
United Alkali. (10)	1 $\frac{1}{8}$ 1 $\frac{1}{8}$	1 $\frac{1}{8}$ 1 $\frac{1}{8}$
Ditto. Pref. (10)	8 $\frac{1}{8}$ 9 $\frac{1}{8}$	9 $\frac{1}{8}$ 9 $\frac{1}{8}$
Val de Travers	1 $\frac{1}{4}$ 1 $\frac{1}{8}$	1 $\frac{1}{8}$ 1 $\frac{1}{8}$



THE CHEMICAL WORLD

A MONTHLY JOURNAL
OF
CHEMISTRY AND CHEMICAL ENGINEERING

EDITED BY W. P. DREAPER, F.I.C.

"Science moves, but slowly slowly, creeping on from point to point."—TENNYSON.

VOL. II. No. II.

NOVEMBER, 1913.

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Truly Rural.

In childhood's days we all, at some time or other, have played at the game of "let's pretend." It seemingly appears that this may also be played by grown-up people. The Chelmsford and Malden District Council proposes to appoint a medical officer of health at a salary of £600 per annum. The officer who is to be appointed, according to *The Lancet*, "will also have to act as water analyst and bacteriologist, and provide any office, laboratory, and assistance he may require for this purpose." For this extra duty he will receive the sum of £50 per annum.

The Lancet rightly states that to provide a laboratory of any real value would entail an expenditure of (at least) £100, and rent, maintenance, and depreciation would certainly cover another £100 per annum. It is with exceptional pleasure that we quote the opinion of our contemporary on this proposal.

"No doubt it is desirable that medical officers of health should have some knowledge of practical chemistry and bacteriology, but it should be remembered that an officer cannot both be spending his time in the laboratory, and attending to his other and generally more important duties. Moreover, most laboratory work requires to be done when epidemic diseases are most prevalent, that is just when there is least time to spare for such work. On the whole, it seems desirable that chemical and bacteriological work should be done in properly equipped and staffed laboratories, . . . since it is quite certain that in a district such as has been referred to above the medical officer of health will find quite sufficient to do without having this additional work thrust upon him."

It is unfortunate that sanitary authorities in this country may still consider that these important duties can be met by such conditions, especially when they apply to a district which covers 220,000 acres, and supports a population of some 60,000 persons.

In view of certain opinions which were current in the past, the attitude now taken up by this leading medical journal will be welcomed by all who have the respective interests of that profession and the chemist at heart.

The analysis of water is not a duty imposed upon medical officers of health by the Local Government Board. It is to be hoped in the near future that this authority will actively protest against future arrangements of this nature being put forward.

The Farm Demonstrator.

On one or two occasions we have noticed the scheme of industrial scholarships which is being worked in America, under the direction of Professor Kennedy Duncan. We have now to record an equally original movement in connection with agriculture under the direction of the so-called National Soil Fertility League, which acts under the presidency of Mr. Howard H. Gross, who has recently visited this country. This institution has its headquarters at Chicago.

Assuming that in fifty years the United States population will be doubled, the food problem is, in the words of the president, "a situation, and not a theory." The object of the League is educational, and it is worthy to note that the association advises the carrying of a large amount of stock upon the farm. As a result of their successful action in the past, the Lever Agricultural Bill is now before the Senate. This provides for a fixed appropriation from the Federal Treasury of \$10,000 per year to each State, and further additional appropriations, starting with \$300,000 per year, on a basis of rural population. This sum increases every year until a maximum of \$3,000,000 is reached.

The association pins its faith on the farm demonstrator. It allows that agricultural, horticultural, poultry raising, and other schools which have been set up deserve all support, but considers that these do not influence the farmer to the required extent.

The DeKalb County, Illinois, was the first to try this scheme. Professor Eckhardt, of the University of Illinois, was appointed farm demonstrator, and the first year closed with what are described as astonishing results. The corn average was increased by ten bushels per acre, which means an annual additional value of \$500,000 to the district.

As a result the farm lands have increased in value by about \$40 per acre since Professor Eckhardt

commenced operations. In the opinion of one of the leading farmers, there has come with this increase in farm crops an enthusiasm among the farmers which is no less marked. Agriculture has been "viewed from a new angle." In view of such results a movement has also taken place in the direction of the land. The plan of farm demonstration has received the approval of President Wilson.

This new movement, which in its essence is based upon the old English proverb, "No grass, no cattle; no cattle, no manure; no manure, no crops," is one of great interest. "By doubling the yield the cost of production is reduced 40%." "Silos and corn ensilage will double the number of stock that can be fed upon a given area." Such are the statements put before the farmers. Under the suggested conditions the cost of producing hogs and cattle has been reduced 25 to 40%. Such practical results as these have naturally had their influence.

It has been arranged that farm demonstrators, as they are appointed, will act under the supervision and direction of the State College of Agriculture. The results obtained will be watched with great interest, as another example of the practical way in which the Americans are dealing with such matters. It is in the direction of agriculture that science can undoubtedly secure a position which will be appreciated by the general public, and this movement is therefore of importance from every point of view.

Chemistry and Physics.

In view of the conflict between chemists and physicists, concerning certain fundamental differences in the relative point of view they adopt towards the physical basis of matter, the Presidential Address at the British Association meeting calls for special consideration.

Sir Oliver Lodge pointed out that it is always necessary for science to remember that it is an affair of the intellect. That it must examine everything in the cold light of reason, and it is in this factor it has its strength. In the words which he quoted of Bertrand Russell:—

"The kernel of the scientific outlook is the refusal to regard our own desires, tastes, and interests as affording a key to the understanding of the world."

From this point of view there is no room for dogmatic negation or philosophising; the nature of man being the larger thing, and intellect only part of it. From the very fact that science is systematised and metrical knowledge, it can only apply in regions where measurement is possible. Emotion, intuition, and instinct are immensely older than science, and this fact cannot be ignored in a comprehensive survey of existence. That it happens that the philosophers are questioning some of the larger generalities of science, and scientific men are examining well-known and well-established laws of mechanics, which latter may possibly lead to the replacement of the Newtonian scheme by something to which Newton's laws of motion are but an approximation.

A word was said against the modern tendency towards vagueness, which "is now being enshrined

as an idol to be worshipped," and this has, perhaps, a special meaning to the chemist.

The recognition that even Boyle's law and other seemingly simple laws in physical chemistry are only approximately true is modified by the fact that the reasons they are departed from are known. They are modified through the action of a known additional cause. It was rightly insisted that this development is an indication of progress, and not a retrograde step.

INSTITUTE OF CHEMISTRY LECTURE.

At a meeting of the Institute of Chemistry, held at the Imperial College of Science and Technology, South Kensington, on Wednesday, October 29th, the first of two lectures was delivered by Mr. W. P. Dreaper, F.I.C., on "The Research Chemist in the Works, with Special Reference to the Textile Industry."

The lecturer first pointed out the difficulty in expressing opinions which could be universally accepted, for industrial chemists worked under such varying conditions and were influenced by temperament and past training. His remarks should therefore be taken as applying especially to the textile industry.

The total gross value of the textile industry (First Census of Production, 1907) indicated that the value of the textile materials and fabrics manufactured in the United Kingdom amounted to the total of £333,000,000; and 1,253,000 persons were employed in their manipulation. Power to the amount of 1,900,000 H.P. was utilised, and 77% of the firms used coal to the value of £8,137,000. On a basis of one chemist for every 2,000 persons employed, no less than 600 chemists would be utilised in this industry alone, each of whom would deal with an annual gross output valued at over £500,000. A saving of 10% in the coal bill would amount in all to £1,000,000. It would be remembered that one large aniline dye combine on the Continent already employed no less than 700 chemists. The recently made statement that "Science was fast becoming an industry" seemed to apply in this case at any rate.

Stress was laid upon the value of a satisfactory knowledge of the principles underlying analysis to the student entering a works. Actual examples were then given of the difficulties met with in interpreting the figures obtained. The results that the successful investigator might achieve by working out new methods and processes or improving those already employed in works were indicated, and the advantages of secret working also dealt with. Also the effect produced through the stress of competition and the utilisation of new processes on working conditions. The young chemist was urged to spend much of his time in the works, only entering the laboratory when systematic investigation became necessary. The industrial chemist who remained in his laboratory was lost. Knowledge of chemistry was an insufficient equipment, modern research being set on a wide basis and requiring a knowledge of physics, and the power to apply this in many directions. This was demonstrated at every turn.

The work of the textile chemist was then considered in greater detail, and illustrated by reference to developments in Mercerising and Schreiner, and the manufacture of artificial fibres and fabrics. The influence of theory was briefly discussed, special reference being made to investigations which had their origin in observations made in the dye-house.

GAS AND THE ART OF LEADER WRITING.

By PROFESSOR HENRY E. ARMSTRONG.

"GIVEN a weak defence, abuse the plaintiff's attorney" is, I believe, a course of action that is not infrequently adopted and held by some to be the right one to follow. Evidently the leader writer of the *Journal of Gas Lighting* (September 23rd) is of this opinion—the abuse he heaps upon my poor head must mean one of two things: either my shots have gone home or the said gentleman—to use an expressive vulgarism—"don't know where he are"; at all events, he does not know what is seemly and usual in discussion and the impropriety of his language is made worse by the badness of his grammar.

In introducing the discussion, so-called, on the "Utilisation of our Fuel Supplies," at Birmingham recently, in Section B of the British Association, my object was again to focus public attention upon the gravity of the problems and upon the need of organised inquiry into the many issues which such a subject presents. I hold that these problems and issues are not only too numerous but far too difficult to be solved sufficiently soon by individual effort. I trust that we shall continue to hold such discussions until we have achieved our purpose: until a "fuel-conscience" has been established amongst us.

The gas industry is one of the chief misusers of coal, owing to the prehistoric character of its methods: on account of the very large amount of capital invested in gas undertakings, it is most important, therefore, to bring home to the public the position in which they stand as investors and the need there is of reforming the processes of manufacture and of placing the industry upon a broad and sound scientific basis.

In reporting me, *The Gas World* heads one of its sections "Drop the Engineer and take up the Chemist." Such was not my recommendation; I suggested only that there should be due co-operation of engineer and chemist. In so far as the storage, meterage and delivery of gas are concerned, the industry is the affair of the engineer; but the initial stage, that of production and purification, is one involving a constant succession of chemical changes of which he has no understanding: it should be primarily under the direction of the competent chemist. The gas engineer, too, has not only been ignorant of chemistry: even as an engineer, he has rarely enjoyed any systematic training but has usually grown up in the works; he has, therefore, been merely a so-called practical man, with all the virtues but also with the faults of this engaging genus—one of these faults being intense belief in himself and if possible, a more intense disbelief in others.

This question of the relative position of chemist and engineer in works, perhaps not even especially

in gas works, is one that has to be fought out in the near future. The engineer is a very peculiar when not an arrogant person; I have been led to think that he forms a species of his own—that he represents a special type of mind, mainly constructive, rarely analytic:

"Theirs not to reason why,
Theirs but to do and die."

And very wonderful are the tasks engineers have accomplished in the application of the mechanic arts.

A couple of years ago, when my retirement was announced, some of my friends, who apparently thought more of me than do the luminaries of the gas world, did me the honour to entertain me and in reviewing my career I ventured to speak of my forty years' experience of different types of students. To quote from the notes in *The Times Engineering Supplement*:

"Professor Armstrong with characteristic incisiveness ventured the opinion that those who enter a technical college with the object of becoming chemists and those who seek to become engineers are entirely different creatures. The one class views things in respect to inward constitution, the other is content to take things as they are and is bent upon applying the available powers to shaping the given materials into useful forms. It was a hint that the time is approaching when scientific methods of selection may be applied to candidates at the threshold of their professional careers."

At the present day it is impossible to over-estimate the value of the engineer: the world moves and has its being under his direction; but it is not sufficiently realised, perhaps, that he works very largely with borrowed intellectual funds, and is mainly engaged in carrying the ideas and wishes of others into execution. The capitalists who are his backbone are now claiming that their capital is not and cannot be properly utilised by him except with their assistance and unless they are called in and allowed to work with him, not merely under him, in a spirit of harmonious co-operation.

Not only has the engineer little time in which he can study chemistry; on the average, I believe, he is incapable of learning it: he can be taught much of the elements of scientific method that is of the greatest value to him in his profession but you cannot make a chemist of him, nor is it desirable that you should. Out of the many hundreds of engineering students who have passed through my hands, Mr. Humphrey, the gifted inventor of the gas-engine pump, is the only one I have known to

take a real interest in chemical work and do it effectively.

Modern industrial requirements can only be met by effective co-operation of all the serious interests concerned: this the Germans have proved to demonstration in their great colour works; in these chemist, commercial man and engineer have been made jointly and severally responsible in the management of affairs; in consequence, they have succeeded where we have failed. The one great exception to prove the rule that we can refer to is that of Brunner and Mond, the one the man of business, the other the iron-willed chemist gifted with engineering instincts, though chemist first and foremost. In this connexion it is worth while pointing to what Mond did for gas—the great step forward he took in saving nitrogen. If a Mond were to take it in hand, ten years from to-day the gas industry would not know itself.

My gassy (as the dictionary gives the two words as synonymous, may I not say inflated?) critic writes: "The chemists associated with the gas industry will also read with interest to themselves, and sympathy for the Professor, the view that 'chemists worth calling chemists have been excluded from the industry.'" How many either have been or are now admitted? If I be not misinformed, my valued friend Dr. Coleman, who held a brief from the companies at Birmingham, when chemist to the gas company there, was denied effective entrance into the works. I believe that now a more enlightened policy prevails and that the works are largely under the direction and control of well-paid, competent chemists. It is, therefore, significant that in Birmingham the gas industry is advancing in many directions. I am satisfied that my statement that the chemist has been kept out of the way and of set purpose, in most cases, cannot be disproved. It was only when the industry realised quite recently that it was in Queer Street and fast falling into disrepute on account of its ignorance of an all-important section of its own business, that an appeal was made to the chemist and an inquiry started into the efficiency or rather I should say, perhaps, the inefficiency, of the gas fire—at Leeds; and even then the attitude taken up by the representatives of the industry was altogether illiberal at first. It has little right now to claim virtue of necessity.

Of course there are chemists and chemists, just as there are engineers and engineers—gas engineers and gas engineers. No engineer thinks of ranking the able mechanic as engineer; there are many able mechanics in our profession also but we have yet to draw the distinction between mechanic and master chemist—between those who are but mechanics and those who have put on the thinking cap. Something must be done to raise the status of the thinking chemist, so that the word may generally spell more than £100 to £150 per annum. Action is required not merely in the interest of the profession, but also in that of the public.

It is unfortunate that I have hurt the feelings of the coal gas industry by speaking of their process

as barbarous; the pity of it is, the indictment is a true one. The Americans saw this at once and make water-gas directly by a rational process; our gas companies make it indirectly by an irrational process. After the first outburst of vapours and gases produced by the decomposition of fatty matters in the coal, a stage comes during which, apparently, hydrogen and oxygen are gradually given off as water, which, however, is at once unburnt to hydrogen and carbon monoxide: this latter stage requires a very high temperature and the few thousand feet of water-gas it affords are produced at considerable cost and in a most unscientific manner. But to deal with such a subject properly much space would be required and more time than I have at my disposal at the moment.

I will refer to only one other point. According to the *Journal of Gas Lighting*, I stated at Birmingham that "a few years ago an Act was passed by which the manufacturers of gas were prevented from removing the sulphur in the way which they had done formerly." I do not think I spoke of prevention and I am confirmed in this opinion by the fact that *The Gas World* reports me as saying: "A few years ago, owing to the persistent efforts of Sir George Livesey, an Act was passed by which gas manufacturers were relieved from removing the sulphur in the way they had done previously." Whether they were prevented or relieved matters little, however; as a matter of fact, for a time they deluged consumers with sulphur, much to the detriment of household fittings and much to the detriment of the shareholders' interests; probably indeed, in the long run, the presence of an excess of sulphur in gas will weigh more against its use and more in favour of electricity than any other consideration: no amount of whitewash on walls or ceiling will suffice to remove the objection. I desire here absolutely and openly to challenge the altogether misleading statements on this point made by Professor Vivian B. Lewes, in his lecture at Manchester, October 8th, 1912, which is being circulated by gas companies.

To quote my critic once more: "The paper contains many other flights of imagination which suggest that Professor Armstrong is living very much at the rear of present-day things in the matter of gas application and manufacture." My mentor, apparently, has not sufficient imagination to remember that those "behind the scenes" are usually credited with seeing most of the play. At all events, may I suggest to him that those who live in g(l)as(s) houses should not lightly cast stones?

The signs of progress I see are comforting on the whole. In the past, the gas journals have had nothing but abuse for my advocacy of soft "smokeless" coke as a fuel in place of smoke-producing coal. Now they are beginning to admit—between the lines—that there may be something in the proposition: they have soft words for Dr. Beilby's soft material, though as described it is obviously inferior to that which I advocated.

In view of the fact that, at no distant date, except perhaps in a few special cases, the use of

smokeless fuel *must* be made obligatory, the future in store for the "gas-works"—if they are only wise enough to seize the opportunity—is a great one: they should be the centres from which energy will radiate in each community. But they will distil coal—coal washed free from sulphur (pyrites)—only to the extent that is necessary to drive off volatile constituents which give rise to smoke when burnt and the residue will be a soft fuel which all can use; the gas that is thus produced will be diluted by "water-gas" made by a rational process

and will be supplied as fuel for heating purposes but not for lighting, at least in our homes. Probably the gas-works will find it advantageous to undertake the supply of electricity as well as gas—they will be wise if they even foresee the possibility of electricity coming in as a heating agent. When accomplished, however, the electrical combustion of fuel, to which I look forward with confidence, will supplant all gas schemes—so let the gas interests be prepared, for the unexpected often happens suddenly in these days.

DETECTION AND ESTIMATION OF VANADIUM IN STEEL.

By J. A. PICKARD, B.Sc., A.R.C.Sc.

VANADIUM is seldom or never added to steel in considerable quantity with the intention of preparing an alloy steel of superior qualities. It is chiefly used as a "scavenger" to eliminate impurities by combining with them and carrying them into the slag. As a result, vanadium steel usually contains well under 1% of vanadium, but ferro-vanadium alloys, which are made use of as a convenient vehicle for adding the vanadium, may contain 30 or 40%.

The detection of vanadium offers no great difficulties, as its reactions are at once delicate and characteristic. Usually it is sufficient to dissolve about 0.2 gms. of the sample in dilute sulphuric acid (1:3), adding a slight excess of nitric acid to oxidise the iron and complete solution, followed by a few drops of hydrogen peroxide to the cold diluted liquid. A dark, brownish-red coloration indicates vanadium. The colour is almost discharged by adding a fair excess of ferrous sulphate. Titanium under the same conditions yields a bright, straw yellow solution, but the vanadium colour is always clearly distinguishable, even when considerable amounts of titanium are present. The titanium colour is not at all readily discharged by a considerable excess of ferrous sulphate. Another very characteristic reaction is the rapid formation of a black colour on heating a little of a solution of a vanadium salt with a solution of aniline in dilute sulphuric acid, which also contains a little potassium chlorate. The colour is at first purple, then deep plum, and finally black, and is due to the production of aniline black, resulting from the accelerated oxidation of the aniline by the chlorate in presence of vanadium compounds. The most sensitive test is Gregory's (*C. N.*, 1909, 100, 221), which is not interfered with by titanium, molybdenum, or tungsten, even if present in large quantities, but iron must be separated. The solution containing a little potassium chlorate is taken to fumes with sulphuric acid until all chlorine is evolved and cooled. Twenty cubic centimetres of a solution of strychnine in concentrated sulphuric acid (4 gms. per litre) are then added, when an intense colour immediately develops if vanadium is present,

and attains its maximum intensity in about ten minutes. By comparison with a similarly treated standard a colorimetric estimation may be made.

Separation from Iron and Other Constituents of Steel.—By pouring a nearly neutralised solution of the steel into boiling 10% caustic soda, vanadium is completely separated as soluble vanadate from iron, nickel, manganese, copper, and all but traces of chromium, but molybdenum, tungsten, titanium, and aluminium remain associated. Ammonia containing about 5% of ammonium phosphate (Am_2HPO_4) when added to a solution of the steel precipitates iron, manganese, aluminium, and chromium, and leaves the vanadium in solution with copper and part of the nickel, tungsten, and molybdenum. After dissolving the steel in aqua regia, evaporating to dryness, and fusing the mass with sodium carbonate, adding about .5 gm. of finely powdered charcoal during the last ten minutes of the fusion, and then cooling and extracting with water, vanadium is separated from chromium and passes into solution with the tungsten, molybdenum, and aluminium. Vanadium may be separated from all metals except molybdenum, by proceeding as in the ordinary phosphorus determination, but adding about ten times its weight of sodium phosphate before adding the molybdate. The vanadium is then all included in the phospho-vanadio-molybdate precipitated.

Estimation.—In view of the difficulty of effecting a satisfactory separation, vanadium is not conveniently estimated gravimetrically in complex steels. Volumetric methods, many and various, have been described, and though most approximate to the vanadium content, few accurate methods are known. Quinquevalent vanadium is reduced to the quadrivalent condition in acid solutions by sulphurous acid, ferrous sulphate, oxalic acid, and some other reagents, and is reoxidised by permanganate readily at 60–70° C., and slowly at lower temperatures. Bichromate does not effect reoxidation, but quadrivalent vanadium reduces to some extent the ferric salts of the mineral acids, producing ferrous iron; so that when the quinquevalent compound is reduced by an excess of

ferrous sulphate, bichromate cannot be used to estimate the excess of ferrous sulphate added, unless special precautions are taken. If, however, sodium phosphate, considerably more than equivalent to all the iron present, be added, this reduction may be avoided and bichromate used. Without going into an exhaustive criticism of published methods the following procedures will be found reliable.

Colorimetric Estimation.—(a) Dissolve 1 gm. of the sample and 1 gm. of a similar steel free from vanadium in 10 c.c. of 1:3 sulphuric acid. To each add cautiously 2 c.c. strong nitric acid and heat till the solutions are clear and fumes have disappeared and cool. Transfer to comparison glasses and add 10 c.c. of hydrogen peroxide solution, made by dissolving about 2 gms. of sodium peroxide in 100 c.c. sulphuric acid (1:10). Dilute with water until the solutions are equal in volume, and match the colour produced by the vanadium steel by adding to the other a sufficient quantity of a standard solution of vanadium containing 0.1778 gm. V_2O_5 dissolved in 10 c.c. strong sulphuric acid and diluted to 1 litre (1 c.c. = 0.001 gm. V). The above procedure can hardly yield results accurate to 0.04%, but the following method is much more sensitive.

(b) Dissolve 1 gm. of the sample in 45 c.c. nitric acid (1:2) and add 1 c.c. 10% sodium phosphate. Boil till all fumes are off, cool somewhat, and add carefully 14 c.c. of ammonia (1:1); boil until all ferric hydrate is redissolved, remove from the plate and add 30 c.c. of molybdate solution, shaking well. The vanadium is all co-precipitated with the phosphomolybdate. Filter off on a small, smooth filter and wash free from iron with 2% nitric acid, finally washing with water. Wash the precipitate into a 400 c.c. beaker, add a small pinch of potassium chlorate, and, cautiously, 20 c.c. of strong sulphuric acid, and evaporate on the hot plate till fumes are freely evolved. Remove, cool. Take an amount of the standard vanadium solution, roughly equivalent to the expected amount of vanadium present, add a little potassium chlorate, and, cautiously, 20 c.c. of sulphuric acid, take to fumes and cool as before. When cold, add to each 20 c.c. of a solution of 4 gms. of strychnine in 1 litre of strong sulphuric acid. Allow to stand ten minutes and match the colours by diluting with the stronger with sulphuric acid.

Gravimetric Estimation.—The following modification of Blair's method, though rather long, gives good results. Dissolve 5 gms. of a steel, or pig iron, and correspondingly less of a high vanadium alloy, in 50 c.c. of 1:2 nitric acid. Evaporate to dryness and bake until nitrates are decomposed, taking care that the mass does not splash up on to the sides of the beaker. The mass can then be easily removed from the beaker without appreciable loss. Powder in an agate mortar and fuse with 25 gms. of sodium carbonate and 2 gms. of sodium peroxide in a platinum dish for half an hour at a bright red heat. Boil out the fused mass with water, filter, and nearly neutralise with nitric acid (1:2). Boil off the carbon dioxide, filter if necessary, dilute to

500 c.c. and just acidify—a yellow colour showing the presence of vanadium. Add 5 gms. of mercurous nitrate dissolved in as little water as possible, and a small quantity mercuric oxide suspended in water to neutralise the free acid. Boil, filter, wash with hot water, and ignite carefully after drying. If chromium, tungsten, and molybdenum are absent the residue will consist of vanadium pentoxide, and the weight of vanadium present may be calculated by multiplying by 0.5655. If present, the precipitate must be again fused with 10 gms. of sodium carbonate and 1 gm. sodium peroxide, as before, dissolved in a little water and filtered, if necessary. Pure ammonium chloride is then added to saturation—about 3.5 gms. will be needed for each 10 c.c. The solution is then well stirred and allowed to stand for some time. The vanadium is precipitated as ammonium metavanadate, and may be filtered off, washed with saturated ammonium chloride containing ammonia, ignited and weighed as pentoxide.

Volumetric Estimation.—The volumetric estimation of vanadium by the following method is much more rapid than the gravimetric, and quite as accurate, if performed with care. Dissolve half a gram of ferro-vanadium, or 2.5 gms. of a vanadium steel in 30 c.c. of sulphuric acid (1:3), adding 10 c.c. of nitric acid as the reaction slackens. A little hydrofluoric acid will effect solution if the sample is refractory. Evaporate until fumes are freely evolved. Dilute with 100 c.c. 1:3 sulphuric acid and then with water to 400–500 c.c. Heat to about 60° or 70° and add dilute permanganate solution, drop by drop, until a faint, pink colour persists. Discharge this colour by carefully adding the exact amount of ferrous sulphate necessary. This operation needs a little experience. Now add 50 c.c. of 10% sodium phosphate solution and cool. Add an excess of standard ferrous sulphate solution and titrate back with bichromate, using ferricyanide of potassium as an external indicator. The end point should be taken as reached when no blue colour is developed in the indicator drop for thirty seconds after adding the test drop. On standing for some time a blue colour will develop in all cases. The amount of ferrous sulphate added, less than equivalent to the bichromate used in the back titration, represents the amount oxidized by the vanadium.

$1 \text{ c.c. } \frac{N}{10} \text{ ferrous sulphate} = 0.00510 \text{ gm. V.}$ This method is interfered with by chromium, but not by any other metal commonly occurring in steel. The effect of chromium may be avoided by performing the first oxidation with permanganate in the cold solution instead of at 65°, but care must be taken that enough permanganate is added to produce a really permanent coloration.

The Annual Report issued by E. Merck on Recent Advances in Pharmaceutical Chemistry and Therapeutics once more illustrates the enterprise which characterises this firm. The volume opens with an article running to 71 pages on lecithin, which presents a practically exhaustive account of the literature on this subject.

PRECIPITATION IN AQUEOUS SOLUTIONS.

By W. P. DREAPER, F.I.C.

THE significance of certain reactions in gels as originally described by Liesegang, and more recently studied in detail by Hatschek (CHEMICAL WORLD, 1912, 1, 189) and others, led the writer to experiment in the direction of determining whether the presence of a gel was necessary to bring about stratification. Preliminary experiments (some of which have been recorded *J. S. C. I.*, 1913, 32, 678) indicate that

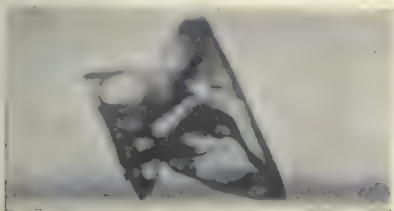


FIG. 1.—LEAD CHLORIDE CRYSTAL 0.7 MM. LONG.

when the experiments are conducted in capillary tubes, with an internal bore of not more than 1 mm. diameter, any disturbing influences due to cross currents and flow are eliminated, and stratification can then be readily obtained in ordinary solutions.

The form of apparatus finally used consists of a capillary tube of about 20 cms. in length. Three centimetres from one end of the tube a bend at right angles is made, and then the tube is filled (by capillary action) with a solution of the substance to be experimented with. The bent end is then sealed in the flame, so that on cooling the tube is entirely filled with the solution. A second tube of larger bore (say 2 mm.) of a length of from 14 to 15 cms., and with a bulb of roughly 2 cms. diameter blown at one end, is filled with the second reacting solution,

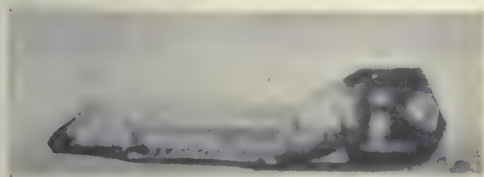


FIG. 2.—LEAD CHLORIDE CRYSTAL 1.5 MM. LONG.

to within 10 cms. of its open end, and suitably placed in a horizontal position.

The capillary tube is then pushed into the outer tube until its open end occupies a position within the bulb itself. The opening at the mouth of the outer tube may then be conveniently sealed by wax, or other suitable material, to prevent evaporation. Any tendency for the capillary tube to alter its position is thus obviated, and it can be withdrawn for examination purposes from time to time, photographed and then replaced in its original position.

Under such conditions results have been obtained which may compare with those obtained in gels, both as regards stratification and the abnormal size of the crystals obtained.

For instance, when the capillary tube contains a 3 per cent. solution of lead acetate, and the outer one a 5 per cent. solution of hydrogen chloride, lead chloride is gradually precipitated in a series of crystals which occur at increasing intervals in the capillary tube. The result obtained in one case is recorded in Table A. When distance along the

TABLE A.

Lead chloride in capillary tube. Diam. 0.66 mm. (internal).

Length of crystals in mm.	Space from centre to centre of crystals.	Actual space between crystals.
(1) .. 3 mm.	(1—2) .. 6.5 mm.	(1—2) .. 3 mm.
(2) .. 4 "	(2—3) .. 8 "	(2—3) .. 4 "
(3) .. 4 "	(3—4) .. 5.75 "	(3—4) .. 2.5 "
(4) .. 0.7 "	(4—5) .. 5.85 "	(4—5) .. 3.3 "
(5) .. 0.5 "	(5—6) .. 6.0 "	(5—6) .. 5.5 "
(6) .. 1.0 "	(6—7) .. 7.75 "	(6—7) .. 6.5 "
(7) .. 1.5 "	(7—8) .. 7.05 "	(7—8) .. 6.5 "
(8) .. 0.6 "	(8—9) .. 8.2 "	(8—9) .. 7.5 "
(9) .. 1.0 "	(9—10) .. 11.75 "	(9—10) .. 9.0 "

tube of the centres of the individual crystals are plotted against distance between the centres of succeeding pairs of crystals on log. squared paper, a straight line curve may be obtained in some cases, indicating that the action of precipitation in succeeding crystals is governed by a simple logarithmic law,

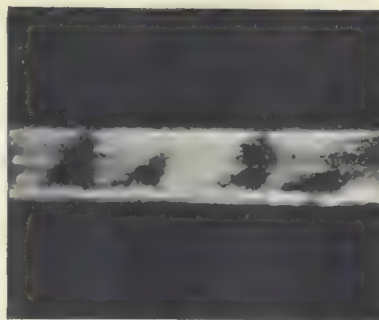


FIG. 3.—LEAD SULPHATE: STRATIFICATION BREAKING DOWN.

which is obviously connected with that of diffusion, although surface action in these capillary tubes may influence the results obtained.

The crystals may take abnormal shape as seen in those photographed *in situ* (Figs. 1 and 2), as they occurred in the experiment recorded in Table A, the direction of the flow of the outer solution into the capillary tube being indicated by an arrow. Abnormal effects were also obtained

with lead ferrocyanide, but the crystals, as Mr. Hatschek has pointed out, differ in their form from those obtained in gels.

When using potassium sulphate in the outer tube, and lead acetate solution in the inner tube, stratification is pronounced, the precipitated lead sulphate occurring in an exceedingly finely divided (or even

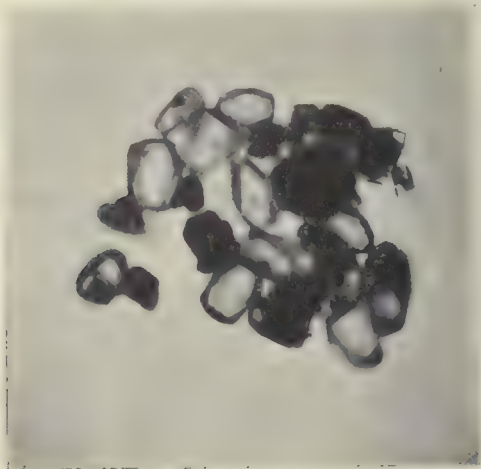


FIG. 4.—LEAD SULPHATE CRYSTALS (AFTER THREE MONTHS).

gelatinous) state. The strata or rings formed persist unaltered for several months, and so far as is known at present, retain their original position. The original precipitate formed within the stratified area may, however, ultimately change into a highly crystalline form (see Fig. 3), when it partly falls to the bottom of a 0.6 mm. tube to the destruction of regularity in the original effect.

In another case lead sulphate was precipitated in the form shown in Fig. 4; but in this case precipitation extends over two or three months from very dilute solutions, giving crystals up to 0.8 mm.



FIG. 5.—STRATUM OF BARIUM CARBONATE IN 0.6 MM. CAPILLARY TUBE.

in length. The larger crystals are those formed further up the tube: the dark masses, the first formed aggregates near the entrance.

With barium sulphate (when the inner tube contained barium chloride, and the outer one a solution of potassium sulphate), a semi-opaque precipitate is first formed in the capillary tube to a length of about

80 mm. That this is also in a state of extreme division, is seen in the fact that it is continuous over the cross-sectional area of the tube, and shows no tendency to settle to the bottom of the tube. It behaves in much the same manner as if it were present in a gel form, which effect is heightened by its semi-opaque appearance. When this length of the precipitate has formed, no evidence of stratification could be observed. Following this, however, stratification effects were produced within this area, the inference being that the barium sulphate present acts in a similar manner to a gel in inducing stratification. Thus the substance originally precipitated may seemingly take the place of a secondary gel, and *itself* induce stratification, when a further amount of the same substance is precipitated within this area. Such conditions may be those originally present in Nature when stratification occurred. In such ways



FIG. 6.—BARIUM SULPHATE IN GEL. (FIRST CONDITION) $\times 100$.

it may be possible to explain stratification without necessarily assuming the presence of a secondary gel.

The photo-micrograph of an actual stratum formed in a capillary tube in the case of barium carbonate, (Fig. 5) sufficiently indicates the physical state of the precipitate formed. This does not, as in the case of silver ferrocyanide, fall to the lower level of the tube, but continues to occupy the position in which it was first precipitated.

Interesting effects may also be observed in a tube of 2 to 3 mm. bore, when barium sulphate is precipitated in the presence of a gel (gelatin). The action during precipitation may be followed in detail under such conditions. The barium sulphate is first precipitated in a finely divided condition, giving an opaque area extending to 8 mm. in length. This is formed within a few hours. It does not increase in length, but advances along the tube, leaving a transparent area behind it, until it reaches within 1 mm. of the surface of the gel, which permanently remains free from precipitate, indicating that this has lost all its soluble barium salt by diffusion. On further standing, the opaque area gradually shortens in length, and ultimately disappears. The clear space in the gel, which is left behind by the advancing

opaque column, is seen on close examination to contain well-defined crystals. The opaque area consists of a finely divided precipitate of insoluble barium salt (Fig. 6), and this changes in the presence of a further excess of potassium sulphate into the highly crystalline salt shown in Fig. 7, the composition of which is yet uncertain.

This point has some interest in view of the fact that the apparently clear spaces between the stratified rings in the ordinary gel experiments are known not to be entirely free from precipitated salts; and, unless in the above experiment actual migration of

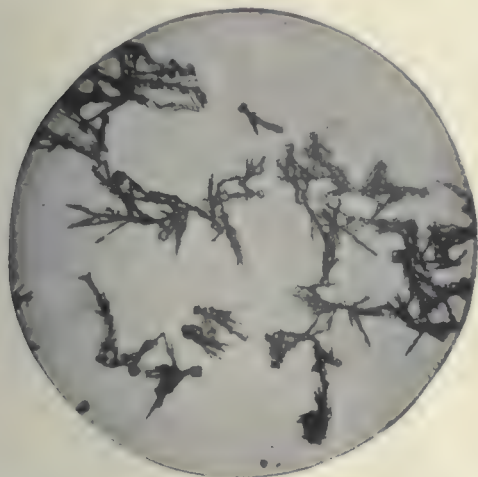


FIG. 7.—BARIUM SULPHATE IN GEL. (SECOND CONDITION.)
× 100.

the first formed precipitate takes place in the direction of the flow of the solution of potassium sulphate, or the barium salt as originally precipitated is to an extent re-dissolved, it is evident that visually a well defined normal stratification may occur, and yet the clear intervening spaces may contain an equal amount of the precipitated salt. Thus, stratification in such cases is due to variations in crystalline form, and is purely visual in its nature.



FIG. 8.—BARIUM SULPHATE SHOWING BOTH STAGES. (ORIGINAL SIZE.)

This fact is well shown in Fig. 8,¹ where the potassium sulphate was allowed to diffuse into the barium chloride gel from both ends of the containing tube. Two opaque areas have advanced in the direction

of the centre of the tube, leaving transparent areas behind them which are as clear as the unaltered area which still remains in the centre between the two opaque areas.

The action may possibly involve chemical as well as physical changes in the first formed precipitate, for it is observed that this change from the opaque to the transparent one, only takes place in the presence of a further excess of potassium sulphate. It is not due to the mere presence of an electrolyte, as excess of barium chloride or other similar substances does not produce a similar effect.

The precipitation of sulphides is being considered, but up to the present time these have not been obtained in a crystalline form, although the tendency

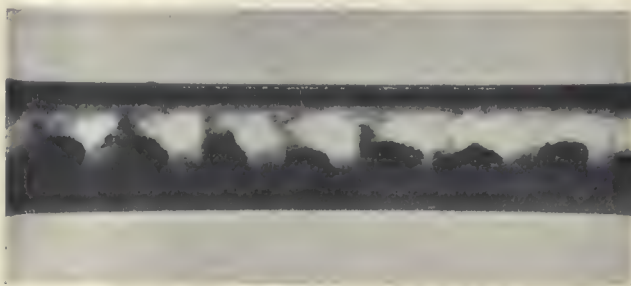


FIG. 9.—COPPER SULPHIDE SHOWING DEGRADED STRATIFICATION.

for the precipitate to stratify is observed with capillary tubes of not more than 0.4 mm. diameter. The precipitate, however, soon falls to the lower level of the tube as seen in Fig. 9.

It would appear that both abnormal precipitation and stratification may occur in the absence of gels when working under the conditions indicated. Also that the substance itself as first precipitated may, in certain cases, induce subsequent stratification within the first area of precipitation. In certain cases where a gel is present there are also indications that a change in crystalline form may be due to change in chemical constitution. Spherulites have not, however, yet been obtained, and these may ultimately be found to indicate the presence of gels (primary or secondary) at the time of precipitation.

As anticipated, experiments in hand show that equally definite results may be obtained in tubes of large diameter. They contain an inert substance in a suitable state of division.

THE FARADAY SOCIETY.

A GENERAL discussion on "The Passivity of Metals," will take place on November 12th next, at 4.30, at the rooms of the Chemical Society. The President-elect, Sir Robert Hadfield, will preside, and the following provisional programme has been arranged: Dr. G. Senter will open the discussion with a general introduction to the subject; Dr. G. Grube (Dresden), will read a paper on "Some Anodic and Cathodic Retardation Phenomena and their Bearing upon the Theory of Passivity"; Dr. D. Reichstein (Zürich) on "Interpretation of Recent Experiments bearing on the Problem of the Passivity of Metals"; Mr. H. S. Allen on "Photo-electric Activity of Active and Passive Irons."

* * *

¹ The blocks of Figs. 1, 2, 3, 5, 6, 7, and 8 are utilised by permission of the Council of the Society of Chemical Industry.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

STREHLENERT'S PROCESS FOR TREATMENT OF SPENT LYES FROM SULPHITE PULP MILLS.

By J. F. BRIGGS, A.C.G.I.

IN the manufacture of sulphite wood pulp the question of the disposal of the spent lyes has always formed one of the most difficult problems to be faced by the manufacturer. For every ton of pulp produced there are 10 tons of spent lyes to be got rid of, containing, in addition to notable quantities of sulphur and lime, nearly one half of the organic substance of the wood. The lyes are highly putrescible, and in many countries the question of their disposal has restricted the location of the pulp mills to the sea-coast or to the banks of swiftly flowing rivers containing a sufficient volume of water at all seasons to serve as an open sewer. The history of the wood pulp industry in the more populated countries is beset with litigation on account of pollution, and more than one successful pulp mill has been shut down on this account alone.

Needless to say, the energies of technical chemists have been seriously devoted for many years to the solution of this problem, and numerous patents have been taken out for the utilisation, or at least the destruction, of these lyes. A detailed record of the various attempts in this direction has been compiled in a small volume by Dr. Max Müller, entitled "Literatur der Sulfitlauge," published in 1911 by the Verlag der Papier-Zeitung. So far as the practical solution of the main problem is concerned, this is a record of comparative failure, but in a few minor directions, such as for binding blast-furnace briquettes and as a tanning agent in the leather industry, some small applications have been found. That such minor applications can only touch the fringe of so large a problem as this is obvious; the waste liquors have to be evaporated in the first instance for ease of transport; secondly, the industry in which it is proposed to utilise the product has to be educated to create a demand; and thirdly, any such demand for the new product is soon satisfied by only a minute fraction of the possible supply.

The evaporation of the spent lyes with the object of burning the organic constituents is a costly process, and the provision of satisfactorily durable evaporating plant presents some difficulty. If it be assumed that the lyes from 1 ton of sulphite pulp contain 1 ton of solid matter dissolved in 9 tons of water, it is calculated that about 14 cwt. of coal would be required for the evaporation. The residue obtained is for practical purposes useless as a fuel, as it contains up to 20% of ash, and the sulphur compounds present create complications which will be readily understood.

In Sweden a large enterprise has been undertaken with a view to extracting alcohol from the fermentable carbohydrates of the lyes. This undertaking is stated to yield a fair return, but there are several reasons against its general validity. The quantity of fermentable sugars present in the lyes represents only a small portion of the total organic matters; enormous volumes of liquid have therefore to be submitted to fermentation and distillation in order to obtain

a relatively small quantity of alcohol. The plant necessary for dealing with this highly dilute alcoholic liquid is extremely costly, and in less favoured countries the exigencies of the excise effectively prohibit the prosecution of such an industry. Moreover this mode of utilisation leaves the main question of the disposal of the wastes untouched. There still remain the large volumes of liquor from the stills, which, although freed from the fermentable saccharine constituents, still contain the main bulk of the original organic matters.

It is obvious that any satisfactory general proposal for dealing with the wastes from sulphite pulp mills must be a self-contained proposition; it must be capable of operation in any pulp mill regardless of location; it should not involve an expensive evaporation process, and it should yield products profitably utilisable in the pulp mill itself or readily saleable on the open market. It is because Strehlenert's process (described in a lecture reported in *Der Papierfabrikant*) fulfils the above conditions that it shows promise, far in advance of any proposition previously put forward, of affording a general solution of the problem which has been a standing reproach to cellulose technologists for so many decades. When it is considered that some couple of million tons of wood substance annually are poured away, ultimately into the sea, the gravity of this reproach will be comprehended.

Strehlenert has realised that the fuel value of the wood substance dissolved in the spent lyes could only be developed industrially after the separation of the sulphur and the lime. He also recognised that the recovery of this wood substance should preferably be effected by precipitation rather than by evaporation. The lignin of the wood, itself an insoluble substance, is held in solution in the spent lyes in virtue of its combination with calcium bisulphite in the form of calcium lignin sulphinate. In this combination the lignin exists only slightly modified; it suffices to decompose the sulphinic acid compound in order to obtain the lignin again in the insoluble form and freed from the sulphur and lime. As the result of this decomposition the major portion of the sulphur combined with the lignin is recovered in the form of sulphur dioxide to be re-utilised in the pulp mill for the digestion of further quantities of wood, whilst the lime is obtained as precipitated calcium sulphate, for which a ready market may be found for various industrial applications.

The principle of Strehlenert's process is based on the decomposition of the soluble lignin sulphurous acid compound by the action of sulphuric acid at a high temperature and under a high pressure. Oxygen is necessary for the carrying out of the reaction and is applied in the form of highly compressed air which is required to procure the precipitation of the lignin in a non-gelatinous form. The amount of sulphuric acid present must be very small in order to avoid carbonisation of the product, and it is found advantageous, in fact practically essential, to produce the sulphuric acid *in situ* by the oxidation of the minute proportions of free sulphurous acid always present in the fresh spent lyes. The decomposition is effected by digesting the

spent lye in an autoclave at a high temperature in presence of air under a high pressure. It is, however, necessary first to remove the lime from the lyes in order to reduce the quantity of ash in the precipitated fuel. This is done very conveniently by adding to the fresh hot lyes a small proportion (1.5 to 2%, according to the quantity of lime present) of sodium bisulphate. A precipitate of calcium sulphate is thereby produced from which the lye is decanted off to the autoclaves for further treatment. The calcium sulphate is drained and washed in centrifugal machines and is recovered as a commercial product.

The lyes freed from lime are charged into pressure digesters to the extent of about 60% of the full capacity of the vessels; the latter are closed and the contents heated up to 100° C. Next, air is pumped in until the pressure rises to about 18 atmospheres. At this stage a rise of temperature of 20° C., owing to the chemical reaction of oxidation, is observed. Heating is continued gradually until the temperature reaches 160° C. At this point all the free sulphurous acid existing in the lye has become oxidised by the air to sulphuric acid. Between 160° and 170° C. there is a critical point at which the decomposition of the lignin sulphinic acid sets in, and a further rise of about 20° C. in temperature is noted as the result of the reaction. The temperature may now be forced up to 200° C. or slightly more, which stage should be reached forty to sixty minutes after starting from 100° C. The operation should then be completed. At the critical point, when decomposition sets in, the pressure in the vessel rises very rapidly, so that a release valve must be opened, and the liberated sulphur dioxide is absorbed in towers for the preparation of fresh liquor. In the last moments of the heating period, a weak current of air must be passed through the lye in order to convert the precipitate to a workable consistence. With too little air it remains gelatinous, with too much it is oxidised too violently and becomes charred. The excess of temperature between 200° and 100° C. in the digester is utilised for heating up a second digester which is ready to start. If the operation has been successfully conducted, the precipitated lignin possesses a sandy character and is easily drained in a centrifugal machine and washed free from soluble sodium salts. The product is dried by means of waste heat which is procurable in the pulp mill.

The process is still only in its early development stages, and the claims of the inventor may not ultimately be fully realised. Much depends on obtaining the lyes in as highly concentrated a form as possible. Strehlenert bases his calculations on the production of 10 tons (10 cub. metres) of spent lye per ton of cellulose. This is, in fact, the proportion actually present in the pulp, but it would appear, from the remarks of various critics, that only about one-half of this amount is directly obtainable by draining the pulp; the remainder is retained and at present has to be washed out in a diluted form. Strehlenert proposes to recover the whole of the spent lyes by displacement with water on the diffusion system, so that he considers his assumption of 10 cub. metres per ton as justified and has based his claims accordingly.

Experiments on a scale of 250 litres of spent lye have been carried out at the Göta pulp mill. On the basis of 10 cub. metres of lye per ton of pulp there were first obtained 140 to 150 kilos of washed calcium sulphate per ton of cellulose. The spent lye contained 11.6% of total dry solids containing total sulphur dioxide equal to 8.6 gms. per litre. The sulphur dioxide recovered for re-use amounted to between 5 and 6 gms. per litre of lye. On the above basis, this would represent 50 to 60 kilos of sulphur dioxide,

or 25 to 30 kilos of sulphur per ton of pulp, directly utilisable on the spot and having a value almost equal to the whole cost of the treatment. The quantity of precipitated lignin substance, after drying, is taken as 600 kilos per ton of cellulose, although in one experiment recorded as much as 74 gms. per litre, or 740 kilos per ton of pulp, were obtained. The calorific value of this lignin fuel, calculated ash-free, is about 7,000 calories, or approximately equal to that of a moderate quality of coal. If each digester be blown off into a succeeding one a considerable economy of heat is effected, and it is recognised that the conservation of heat at all stages is a primary necessity in a process such as this. It is calculated that the heat lost in the digestion process, working with digesters capable of treating 10 cub. metres of the spent lye, is equivalent to 15% of the fuel produced. Taking this at cost price, power, wages and capital charges bring the total cost of producing 1 ton of lignin fuel up to 5 kr. (5s. 7d.), assuming that the fuel may be dried by means of waste heat. A mill manufacturing 20,000 tons of cellulose per annum consumes about 500 kilos of coal per ton of pulp, the coal costing (in Sweden) about 15 kr. (16s. 8d.) per ton. Thus if 600 kilos of lignin fuel are obtainable per ton of cellulose, it is possible that the whole of the coal consumption of the mill may ultimately be replaced by lignin fuel manufactured on the spot at one-third of the cost. Alternatively, the lignin might be subjected to destructive distillation, under which treatment it yields products similar to those obtained by the distillation of wood, including a charcoal which would still be available as fuel. This question of mode of utilisation would depend on local conditions and, mainly, on the cost of coal.

There are a few points of some importance which are still left open in Mr. Strehlenert's account of his proposals at the present stage of development. First, as to the quantity of spent lye fit for treatment obtainable per ton of cellulose, only about 5 cub. metres are drained off in the ordinary way, and special arrangements would be required to recover the other 5 cub. metres. This question affects only the total output of valuable by-products and not the cost of treatment for the manufacture of the lignin fuel, but it is also an important factor in the problem of pollution. It remains to be seen whether the proposed special arrangements would be practically acceptable to the manufacturers and whether the complete recovery of the lyes could be effected at a degree of concentration sufficient for the successful operation of the treatment. Next, more information is desirable as to the nature and quality of the lignin fuel. Strehlenert states that it can be prepared almost free from ash and that it has a calorific value of 7000 cal. It is also stated that if thoroughly dried it burns too fiercely and that it is desirable to leave about 20 per cent. of moisture in the fuel. The evaporation of this moisture would, however, lower the calorific value to some slight extent. No information is given as to experiments on firing with this fuel, nor as to the physical form in which it is fed to the furnace, neither does the inventor state whether a special type of furnace is required other than the ordinary types of steam boilers. Lastly, there is the question of pollution and whether the new process is capable ultimately of affording a satisfactory solution of this problem. Naturally, the first condition for this is the recovery for treatment of the whole 10 cub. metres of spent lye produced per ton of cellulose. Next comes the question of the composition of the effluents after the precipitation of the lignin. Very few data are given on this point. The original spent lye before treatment contained 1.55 per cent. of "sugar," whilst the effluent after treatment contained 0.19 to 0.22 per

cent. The treatment, however, is not one which could be expected to eliminate true sugars, so that these figures require some explanation. It would seem, however, that there is a very considerable, although not complete, purification of the lyes from cupric reducing substances, and considering that the whole of the lignin is also removed, there must result a very great mitigation of the pollution nuisance, sufficient, probably, for all practical purposes. Strehlenert, however, does not discuss his process from this point of view; he puts it forward as a profitable accessory industry capable of converting a troublesome waste material into useful products. The new industry would be self-contained and therefore capable of that unlimited expansion which would be necessary when dealing with so vast a problem. If its technical development can be successfully achieved, the benefits to the cellulose industry and to the world at large will be incalculable.

THE CHEMISTRY OF MODERN ROAD-MAKING.

By ERNEST FEILMANN, B.Sc., Ph.D., F.I.C.

UNTIL a very few years ago the special application of chemistry to the problems of road-making was negligible or extremely small; but with the advent of self-propelled vehicles on our highways a very different state of affairs has arisen. Road engineers have had to deal with the wear and tear caused by an increasing traffic, at high speeds, and also with vehicles possessing a dead weight hitherto almost unheard of. The consequence of these conditions was that the old waterbound macadam roads were rapidly worn down, and that, in addition to the heavy cost of repairs and general bad condition of the road surface, dust was produced in quantities hitherto unknown, to the detriment and danger of the public.

The practice has, therefore, become general of either coating the road surface with tar or mineral bitumen, or of incorporating such substances with the metal of the upper layers of the road itself, and, most frequently, a combination of these two methods is employed where the traffic is heavy. The object of the binding material in the layers below the surface is to minimise the attrition of the lumps of granite or other rock of which the road metal is composed; in an ordinary waterbound road these lumps are rubbed against one another in the course of the wave motion to which the layers of the road are subjected every time that a heavy vehicle passes over its surface, and, with the help of the water, which percolates fairly freely through such a road, the road metal is converted into mud at a rate which, under the influence of modern traffic conditions, causes the evils mentioned above. The organic binding materials which are now used prevent this attrition to a greater or less degree in two ways: firstly, by reason of their viscosity, they largely prevent the particles of road metal from moving relatively to one another, and, secondly, they further reduce the attrition produced by such friction as may still occur by preventing access of water. The surface coating of organic material also serves at least two functions; one of these is to render the road surface waterproof, and thus protect the layers below, whether these are mixed with an organic binder or not, and the other to increase the durability of the surface itself, give it the requisite degree of smoothness, which must not be so extreme as to become slippery, and the requisite hardness and resiliency. The qualities which are desirable in an organic binder for road-making

purposes are therefore: a high degree of viscosity when set; a sufficient fluidity as used for mixing or surfacing, which is usually in the hot condition, so that it may possess the requisite penetrating power; sufficient elasticity or resiliency to enable the road, after momentary distortion under the influence of the traffic, to resume its original form; sufficient chemical and physical stability to retain the above-mentioned properties for as long as possible; and absence of poisonous or otherwise noxious ingredients in sufficient quantity to pollute streams or to be otherwise harmful. The organic binders which have hitherto been used are almost entirely comprised in the following categories: Crude coal tar; distilled coal tar; various petroleum residues, commonly designated "bitumens" in this connection; and true mineral bitumens, or asphaltes, such as those of Trinidad or Val de Travers.

Crude gas tar can only be used for road surfacing and dust laying, and opinions vary considerably as to its suitability for these purposes; much prejudice against its use prevails in localities where there are valuable fisheries, but the proof of actual damage from this cause appears to be uncertain; on the other hand, laboratory experiments with live fish indicate that this danger is small, and possibly negligible, a conclusion which much practical experience tends to support. At the same time it must be admitted that phenols, and more particularly various ammonium salts, which this substance contains, are highly poisonous to fish and other organisms when in sufficient concentration; it is a very debatable point whether, given reasonable care, such concentrations are ever reached in the water-courses in practice. The tar is ordinarily applied to the road surface in a hot condition, necessitating the use of portable boilers, and so forth, and the transport of fuel to the point of application. By means of another process, the tar is sprayed cold into the road surface in the form of a coarse, temporary emulsion, by agitation with certain aqueous solutions, and in this manner much labour, time and expense are saved.

"Distilled" tar has been heated to, approximately, 170° C. to remove water, ammonia and its compounds, and light oil. It is much used both as a surfacing and as a binding material; in the latter case it is either mixed with the road metal whilst hot and then rolled in, or the hot tar is poured on to the road metal after this is in position, this operation being known as "grouting." Granite, or other rock, incorporated with distilled tar is known as tar-macadam; distilled tar is also frequently used with blast-furnace slag (Tarmac, etc.). There is still much uncertainty regarding the connection between composition and efficiency of distilled tar for road-making; it seems to be well established that an excessive amount of free carbon is deleterious, probably because this is an indication that the tar has been overheated at some stage, with consequent destruction or alteration of those compounds on which its efficiency mainly depends; it is also generally recognised that an excessive amount of naphthalene is undesirable.

With regard to *bitumens* and *asphaltes*, there is also much variety of opinion as to criteria of quality; the first cost of using these substances is higher than that of tar, but, on the other hand, the results are more durable, though for ordinary traffic conditions up to the present tar-macadam and similar preparations have proved sufficiently durable for practical purposes. The resiliency of asphalte is greater than that of tar. It seems to be fairly well established that the best bitumens and asphaltes contain high percentages of compounds which are sulphonated by strong sulphuric acid, and usually contain considerable amounts of sulphur.

MOLECULAR PHYSICS.

By J. A. CROWTHER, M.A. (Fellow of St. John's College, and Demonstrator in Physics in the Cavendish Laboratory, Cambridge.)

CHAPTER VII.

THE ATOM IN VIBRATION.

It can easily be shown that when a moving electric charge is accelerated or retarded in any way, a wave of electromagnetic disturbance radiates out through the surrounding space. Consider an electron with its Faraday tubes moving along in the direction AB (Fig. 24). If the electron is moving with uniform velocity these tubes will travel along with the electron as if they were rigidly attached to it. Suppose, however, that this electron on reaching a point C is suddenly stopped in its career. The ends of the Faraday tubes attached to the electron are suddenly brought to rest.

Now a Faraday tube is in some respects very like a stretched rope. For instance, it has a tension along its length, and possesses, as we have seen in a previous chapter, mass. Thus, just as when one end of a rope is jerked, a certain definite time elapses before the displacement reaches the other end, so a displacement in a Faraday tube does not reach all points of it simultaneously, but is propagated along it with a definite velocity. In the case of the

stretched rope the velocity is equal to $\sqrt{\frac{T}{m}}$ where T is the tension on the rope and m its mass per unit length. On similar principles it can be shown that the velocity of a disturbance along a Faraday tube is equal to $\frac{1}{\sqrt{\mu K}}$ where μ is the magnetic permeability and K the specific inductive capacity of the medium through which the disturbance is travelling. We will call this velocity V .

Now, during the time it has taken for the jerk to travel from the electron O to a point P, the portion of the tube beyond P, not having received the signal that the electron has been stopped, has been travelling on with its original velocity and is now in the position P', where PP' is the distance which the electron would have gone in the time taken for the disturbance to travel along the tube from O to P. Thus a kink is developed in the tube which travels outward along it with the velocity V .

The bent portion of the tube PP' is moving perpendicular to its length and will thus, by the principles we have already developed, produce a magnetic field in the medium which will also travel out with the kink. If we consider all the tubes surrounding the particle, it will be seen that these bent portions will form a kind of sheet of disturbance travelling outwards as an expanding spherical shell or wave.

If we can determine for any medium the values of μ and K in the same system of units, we can calculate the velocity V with which the disturbance

is propagated in that medium. It will be remembered that the electrostatic system of units was obtained by defining K the specific inductive capacity of air as unity. The electromagnetic system on the other hand assigns this value to μ the magnetic permeability of air. The comparison of the two systems can best be performed by measuring the capacity of the same condenser according to both systems of units. This operation is described in most text-books of electricity, and its details are outside the scope of our present work. The results obtained are, however, most striking and important. The result of a long series of experiments at the American Bureau of Standards extending over several years has given a value for V of 2.997×10^{10} cm. per second. This is, within the limits of experimental error, identical with the best determinations of the velocity of light, which have given a mean value of 2.998×10^{10} cm. per second. The agreement between the values obtained for the two velocities is too close to be accidental. It affords

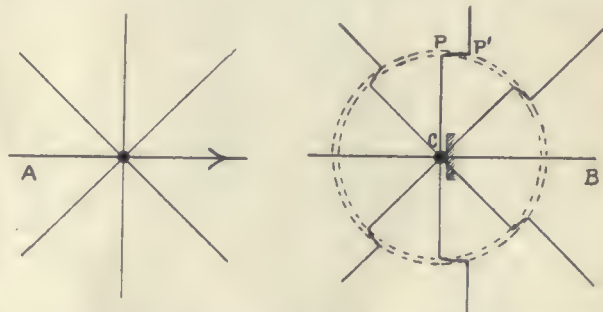


FIG. 24.—PRODUCTION OF ELECTROMAGNETIC DISTURBANCES BY THE STOPPAGE OF AN ELECTRON.

a convincing proof of the electromagnetic nature of light.

In the case we have considered where the particle is suddenly brought to rest a single pulse is formed the thickness of which is equal to the distance through which the disturbance can travel in the time taken to stop the particle. Such pulses are given out when cathode rays in a discharge tube impinge on a solid anticathode. They give rise to the well-known phenomena of Röntgen or X-rays.

If instead of stopping the particle dead we cause it to oscillate about a mean position, a series of undulations will be set up in the Faraday tubes attached to it, such, for example, as are seen when one end of a long rope is shaken regularly to and fro. Thus a series of electromagnetic waves move out from the vibrating electron, their frequency being equal to the number of vibrations made by the particle per second. Their wave length is equal to the distance travelled by the disturbance during the time of one complete vibration. If this lies between .0004 and

0.0008 mm. these waves will produce on our eyes the impression of light. This, in its crudest form, is the Faraday-Maxwell electromagnetic theory of light.

Not only may light originate in the vibration of electrons; all our experiments drive us to the conclusion that such vibration is the only way in which such light can be produced. Uncharged matter is apparently quite incapable of setting up any kind of disturbance in the æther. It is the electric charge which serves as the only link between the two.

We can, however, proceed further than this. Modern research has enabled us to identify with certainty the vibrating systems which emit the myriad lines in the spectra of the elements with the electrons, with the properties of which we are now growing familiar.

Michael Faraday, with almost uncanny prescience, seems to have felt that the relation between magnetism and light must be of the closest, and sought for it with unremitting diligence. It is one of the little ironies of life that the only effect which he did discover (the magnetic rotation of the plane of polarisation) was one of the very few phenomena

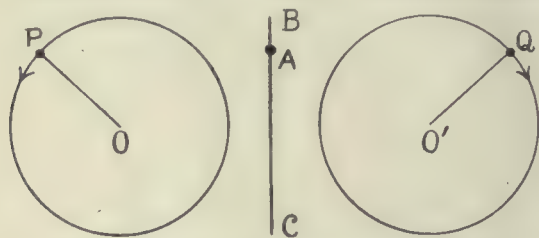


FIG. 25.—ILLUSTRATING THE DECOMPOSITION OF A HARMONIC MOTION INTO TWO CIRCULAR VIBRATIONS.

which his theory even now is hardly adequate to explain. The effect he sought for was not discovered until, more than thirty years later, his experiments were repeated with stronger magnetic fields and far more powerful methods of spectrum analysis by Zeeman.

He found that if a source of light was placed between the poles of a strong electromagnet and the light emitted was examined spectroscopically, a curious change took place in the appearance of the different lines in the spectrum, each being split up or decomposed into two components when the light was viewed along the lines of force in the magnetic field, or three when viewed at right angles to this direction.

Let us consider briefly the effect of applying a magnetic field to the charged particles emitting the vibrations as they oscillate about their mean positions. In general the path described by the particle will be somewhat complicated. We can, however, resolve its motion in the usual way into vibrations parallel to and at right angles to the lines of force in the magnetic field. The vibrations performed along the lines of the field will be unaltered by the application of the field since the latter produces no mechanical effect on a particle moving in its own direction.

It will be quite different with those vibrations which are executed in directions at right angles to

this. It is shown in works on mechanics that any harmonic vibration can be regarded as the sum of two circular motions of properly chosen amplitude and phase. For example, the harmonic motion of a particle A vibrating along the straight line BC (Fig. 25) is exactly equivalent to the motions of two equal particles P and Q describing the circles shown in the diagram with equal velocities but in opposite directions.

It will be sufficient, therefore, and will lead to no loss of generality if we consider the charged particles as describing circles at right angles to the magnetic field, under the action of forces directed towards the centres of the circles. Since the motion of the charged particles is now everywhere at right angles to the magnetic field there will be a mechanical force acting on the particles which will be everywhere at right angles to the magnetic field, and to the direction of motion of the particles. A little consideration will show that it must always act in the line joining the particle at any moment to the centre of the circle.

Particles such as P and Q are, however, describing their circles in opposite directions. Thus the magnetic force will be in one case directed towards, in the other away, from the centre of the circle. In the first case the total force dragging the particle towards the centre is increased; the circle is contracted and the time of vibration becomes more rapid. In the latter the effective force is diminished, with the result that the orbit expands and the vibrations become slower.

An apple whirling round at the end of a string will furnish a very useful analogy. If the tension of the string is increased the apple is drawn in and its revolutions become more rapid. If, on the other hand, the tension is relaxed, the apple takes a wider sweep, while the time it takes to complete a single revolution becomes longer.

Thus, instead of all the particles describing their orbits in exactly the same time and thus producing light of one frequency only, one set have been accelerated, the other retarded by the magnetic field, so that instead of a single line the spectroscope will reveal two, one on each side of the original position of the line. By optical means we can distinguish between clockwise and counter clockwise vibrations, and can thus determine which of the two has been accelerated and which retarded by the magnetic field. Since the effect on a positive particle would be exactly the reverse of that on a negative, we can thus determine the sign of the charge carried by the vibrating particle. In every case so far examined it has been found to be negative.

If we view the flame along the lines of force, these two new lines are the only ones seen, as the vibrations taking place in the line of sight produce no effect on the eye. If, however, we look across the field, the vibrations executed along the lines of the field will also produce their effect in the spectroscope, and since their period is unaltered by the field they will give a line in the position of the original undecomposed line. Since all the circular paths

are being now viewed end on, all three lines will appear to be plane polarised. These results are shown diagrammatically in Fig. 26.

This in its simplest form is exactly the effect discovered by Zeeman in 1896. He found that if a source emitting a line spectrum were placed between the poles of a very powerful electromagnet and viewed with an interference spectrometer of high resolving power the line was split up into three components when viewed at right angles to the magnetic field and into two when seen along the lines through a hole in the pole piece. This is very well shown in the photograph reproduced in Fig. 27. When, at the suggestion of Lorentz, who at once saw the correct explanation, the polarisation of the different components was examined, it was found to agree exactly with that predicted above.

We have seen that these observations have shown that the vibrating system is negatively charged. We can, however, go further than this. Following up the argument given above it can easily be shown that if λ_c and λ_e are the wave lengths of the two

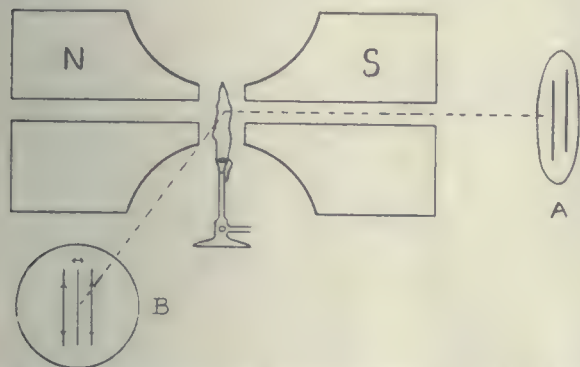


FIG. 26.—ILLUSTRATING THE ZEEMAN EFFECT. N, S ARE POLES OF ELECTRO-MAGNET. A B REPRESENT THE APPEARANCE OF A SINGLE LINE EMITTED BY THE FLAME AS SEEN THROUGH A SPECTROSCOPE PLACED IN THE TWO POSITIONS.

outer components into which a single line of wave length λ_0 is split up

$$e/m = \frac{\lambda_c - \lambda_e}{H \cdot \lambda_0^2} \cdot 2 \pi V$$

where e/m is the ratio of the mass to the charge for the particles and V is the velocity of light. Now Runge and Paschen found that for a certain series of mercury lines, for example, the value of $\frac{\lambda_c - \lambda_e}{\lambda_0^2}$ was 2.14 for a magnetic field of 24,600 units, while V is of course 3×10^{10} cms. per second. Substituting these values in the equation we have

$$e/m = \frac{2.14 \times 2 \pi \times 3 \times 10^{10}}{24,600} \text{ or } 1.65 \times 10^7.$$

Considering that the displacement produced by even the strongest fields amounts generally to somewhere about one-fifth of the distance separating the two D lines of sodium, it will be seen that this result agrees even better than might have been expected with the value of the same ratio 1.77×10^7 deduced for the negative electron from experiments on cathode rays. The identity of the light-emitting

systems with the cathode ray particles must be regarded as established beyond all challenge.

Many spectral lines show the Zeeman effect in this simple form. Others, however, give more complicated effects, some of the lines of Molybdenum, for example, splitting up into seventeen and even nineteen components. We have, in assuming that the vibrating electron executed harmonic vibrations, neglected the possibility of its motion being disturbed by the forces due to neighbouring electrons in the same atom. If these are not negligible complications ensue, and the time of vibration is no longer independent of the direction in which it takes place. The matter has been discussed at length for certain simple systems of electrons by Professor Sir J. J. Thomson, and his paper may be found in the *Proceedings* of the Cambridge Philosophical Society, Vol. 39, by any who are interested in pursuing the matter more deeply.

The lines in the spectra of an element thus

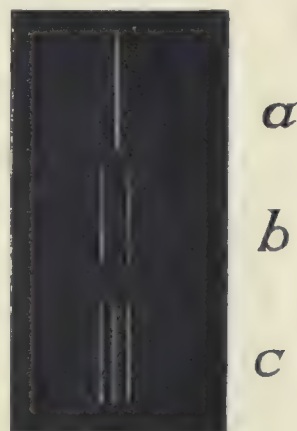


FIG. 27.—THE ZEEMAN EFFECT. (a) UNDERCOMPOSED LINE. (b) SAME LINE VIEWED ALONG THE LINES OF FORCE OF A MAGNETIC FIELD. (c) LINE VIEWED AT RIGHT ANGLES TO LINES OF FORCE.

represent the different modes of vibration of the electrons connected with it. It might seem that with a complete knowledge of these periods at our disposal it should be possible to reconstruct the atom with certainty. Theoretically, no doubt, this should be so. The mathematical difficulties are, however, appalling, and only in the case of a few very simple systems is the analysis at all possible. Thus the results to be looked for from spectroscopy are at present qualitative rather than quantitative.

Even so, however, a study of spectra is most luminously suggestive. A careful analysis of the innumerable lines which are dotted apparently at random through the spectra of the elements has shown that they are by no means the confused jumble of periods which at first sight they appear to be. It has been found that in very many cases they can be grouped into definite series, every line of which can be obtained by substituting particular whole numbers for a variable quantity " m " in a general equation the form of which is the same for all elements. (To be concluded.)

FRUITS OF RHODESIA.

By LOUDON M. DOUGLAS, F.R.S.E.

(Continued from page 324.)

NATIVE beans, cow peas, or velvet beans answer this purpose admirably, and, while they enrich the soil, more especially for the young fruit trees they provide in themselves economic products of considerable value.

There is no question, at present, in Rhodesia of utilising the poorest land, as it will be a long time before such a necessity arises. When that day comes it will be remembered that in Florida, which is one of the citrus gardens of the world, the finest fruits are grown on barren land, which is dressed regularly with the manurial elements required for the growth of the trees and the fruit.

As has been indicated, it is a mistake, as a rule, to attempt to grow fruit on exceptionally rich soil, the returns in such circumstances being principally wood and leaves. Where manuring is needed, the important elements are phosphates and potash.

Fruits vary somewhat in composition, and analyses of various samples of the same variety are not generally quite concordant. On the other hand, the differences between the ordinary fruits of commerce are not very striking, and, for our present purpose it will be sufficient to define limits which will apply to most of them. The following therefore may be taken as the general analysis :—

	Per cent.			
Moisture	80	—	87	
Albuminoids	·25	—	·75	
Sugar	1	—	13	
Organic acids				
Woody fibre	5	—	11	
Gum pecten, etc. ..				
Ash	·50	—	·75	

It is obvious that the feeding value of fruits is not very high, and we must look in other directions for their great and rapidly increasing popularity as articles of diet. A good deal of this, no doubt, is due to their agreeable flavour, but, as frequently happens, the palate is a correct guide to the proper kind of food to be taken when the underlying scientific principle is unknown. The really important thing about fruits is the ash. Take, as an example, that of the apple. It varies a good deal, but the analysis may be generalised as follows :—

	Per cent.			
Oxide of iron	2			
Lime	4			
Magnesia	8			
Potash	45			
Soda	20			
Phosphoric acid	13			
Sulphuric acid	4			
Silicic acid	3·5			
Chlorine	·5			
Total	100			

At a glance we can see that the bases greatly preponderate over the acids, and that there is a considerable excess of alkalinity.

Now let us take the case of meats and certain kinds of grains and seeds used as food, which contain organic phosphorus and sulphur. When these are burnt or oxidised, the phosphorus and sulphur are converted into phosphoric acid and sulphuric acid, to neutralise which the bases present are insufficient, therefore the ash is acid. The digestion of food is, of course, a process of oxidation. The organic acids, etc., in fruits are burnt up in the system leaving the bases with which they were partially combined as carbonates. When meats and other materials containing organic phosphorus and sulphur are similarly digested, an excess of acid is produced which, passing into the blood,



GRAPES IN SALISBURY ARBOUR.

would be very injurious, if it were not taken up and neutralised by alkalies. It is the rôle of fruits and vegetables in dietary to produce the alkalinity required to neutralise this excess of acidity, for the generality of fruits and the majority of vegetables yield an alkaline ash. Of course, fruits and vegetables have other functions in diet; their mere bulk and low feeding value reduce the undue concentration of the stronger foods to a proper average value. At the same time, they stimulate peristaltic activity

in the digestive track. Both from the chemical and physical standpoint, therefore, fruit is a most important article of food, and the rapidly growing demand for it is evidence of a sound natural instinct.

For a considerable time the fresh fruit trade will, no doubt, occupy all the energies of the Rhodesian growers, but the day should come, as in older countries, when a balance will be available for manufacturing purposes, and attention may then be turned to the production of essential oils and citric acid. Indeed, the high range of prices at which these

pests, so that the fruit grower is not much troubled with destructive insect enemies.

A CHEMICAL STANDARD FOR CITRUS FRUITS.

So far it has not been found possible to make a comparative analysis of Rhodesian fruits, and as in many of the fruit gardens they have to rely upon irrigation, this may become an important consideration in the future, as the difference between irrigated and non-irrigated fruit is considerable.

The citrus growers of Florida have, over a long period of time, investigated the question of the constituents of citrus fruit, and have come to the conclusion that a standard should be set up in the case of oranges, and which is stated in the following :

" 1. All round oranges showing a field test of one and twenty-five hundredths (1.25) per cent. or more of acid, calculated as citric acid, shall be considered as immature.

" 2. Provided, however, that if the grower (or shipper) consider the fruit mature he shall have the right to appeal from the field test to the State Chemist for a chemical analysis, and if this chemical analysis shows that the percentage by weight of the total sugar, as invert sugar, be seven times or more than the weight of the total acid as citric acid, the fruit shall be deemed mature.

" 3. That the juices of not less than five average oranges shall be mixed from which



BANANA PLANTS : VICTORIA, RHODESIA.

articles have been maintained since the Sicilian earthquake might almost tempt to experiments in that direction now.

The South American tree, the Paw-paw, which has been introduced to most of the British tropical dependencies, grows well in Rhodesia, and has most probably a future before it. The property possessed by the juice of dissolving fibrin renders it a powerful digestive, and already there is a considerable demand for the extract, especially in the United States of America. The fruit itself, or the residual pulp after extraction, is a capital feed for live stock. Pineapples, the juice of which is also credited with digestive properties, seems likely to become an important crop. The squashes which grow so abundantly in many parts of Rhodesia perform an important point in taking the place of water for drinking purposes, when the latter is not available. In the feeding of pigs especially these squashes are of great value for the production of balanced rations, of which the basis is Indian corn or mealies.

FRUIT PESTS.

The principal pests which have to be dealt with in Rhodesia are of the scale type: the red scale, soft scale, and purple scale, occurring at Umtali, and, to a lesser extent, in other parts of the country. There are, of course, other pests, but none of these have, so far, done much damage, although the orange butterfly (*papilio demoleus*) is sometimes troublesome, and the Citrus Codlin moth is sometimes destructive to fruit. Other fruit trees, with the exception of the fig, are singularly free from



PINEAPPLES AT MELSETTER, RHODESIA.

a composite sample shall be drawn for the field test.

" 4. That the juices of not less than twelve average oranges shall be mixed, from which shall be drawn a composite sample for laboratory analysis."

This is so important a matter in connection with future developments in Rhodesia, that it may be

well to put on record here the method of making this valuable field test.

As will be seen, certain simple apparatus is required, and beyond that, only a little care is necessary in carrying out the test:—

APPARATUS, MATERIAL NECESSARY, AND METHOD OF APPLYING FIELD TEST FOR MAXIMUM ACID IN IMMATURE ORANGES.

APPARATUS.

One 1-quart granite-ware cup.

One lemon squeezer.

Cheese-cloth strainer, 18 ins. square.

One white porcelain teacup.

One 25 cc. pipette.

One quart bottle of alkaline (standard) solution (equivalent to 1.25% solution of citric acid).

One 2-oz. bottle, with dropper, or indicator (phenolphthalein).

Cost, approximately, 12s. 6d.

Peel five oranges, cut across plugs, squeeze and strain through the cheese-cloth into the granite cup. (Throw cheese-cloth and pulp away. Do not attempt to use cheese-cloth twice.) Rinse with alkaline solution and fill pipette to mark 25 cc. with alkali solution and place contents in teacup. Carefully rinse pipette with orange juice, then fill pipette to mark 25 cc. with orange juice and add to alkaline solution in teacup. Mix by revolving cup. Drop several drops of "indicator" into the mixture. If the acid be less than 1.25%, a change of colour will occur—orange to pink. If the acid be greater than 1.25% there will be no change in colour. The alkaline solution must be of exact strength to neutralise an equal volume of citric solution, containing 1.25% of citric acid.

In view of the huge possibility of the Rhodesian citrus industry, the value of a fixed standard of acidity in the fruit cannot be over-estimated, as it appears to be the one method of control likely to ensure uniform production. It will therefore be to the advantage of fruit growers in Rhodesia to become familiar with this test, as if it is adopted, it is likely to establish great confidence in Rhodesian fruits when they come to be offered to European markets in the near future.

It will be recognised that the fruit industry of Rhodesia is likely to reach great proportions, inasmuch as the natural conditions of fruit growing, in climate, soil, and sunshine all exist there. It only remains for the fruit grower to take advantage of the experience of other countries, and, by organisation, establish an export trade to Europe.

The country is too young to allow of anyone laying down hard and fast rules as to what kind of fruit growing will be most profitable. No doubt there will be many experiments tried in fruit drying, and in canning, and it may be found that, considering the geographical position of Rhodesia, these industries may develop largely, alongside of the fresh fruit trade, but, in any case, there is abundance of

evidence to show that in a very short time the citrus fruit industry of Rhodesia will be one of the most important in that country.

PERSONAL AND OTHER NOTES.

THE Council of the University of Leeds has granted six months' leave of absence to Professor Smithells, who has left England for Lahore, where he is to give a course of lectures and to assist the Punjab University in other ways in the promotion of scientific education and research.

Mr. W. Harrison, of the Manchester Municipal School of Technology, has been appointed research chemist to the Joint Committee on Ventilation Research of the Institution of Gas Engineers and of the University of Leeds.

Professor P. F. Frankland has been elected Dean of the Faculty of Science in the University of Birmingham in succession to Professor S. M. Dixon.

Mr. C. R. Bury has been appointed Assistant Lecturer and Demonstrator in Chemistry at the University College of Wales, Aberystwyth.

£10,000 has been given anonymously to the Leeds University in connection with proposed developments in the department devoted to agriculture.

Science announces that M. Ernest Solvay, the discoverer of the Solvay process for the manufacture of sodium carbonate, celebrated the fiftieth anniversary of that discovery on September 2nd last, at Brussels, by giving more than £200,000 to educational and charitable institutions. The Universities of Paris and Nancy, each received £20,000.

The director of the Rothamsted Experimental Station asks us to give publicity to an appeal for £6,000 for purposes of completing a centenary commemoration laboratory. When this is completed this station will be able to deal with the complete investigation of the numerous problems connected with soil fertility. If £6,000 can be subscribed by public subscriptions, a further £6,000 will be given by the Development Commissioners. It is pointed out that Rothamsted is the oldest and has been for many years the best agricultural station in the world for the study of soil fertility problems. It is with the object of helping Rothamsted to maintain its supremacy in this direction that the present addition is contemplated.

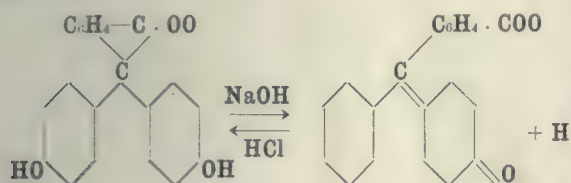
Nature announces that a strong committee, mainly consisting of old students of the Royal Agricultural College, Cirencester, is about to issue a special appeal, with the view, in the first place, of collecting the balance of £1,685 still required to complete the £5,000 necessary to secure the advance of a similar sum from the Development Fund for erection of King Edward's wing of the college. When this sum has been subscribed, the appeal will still be continued so as to provide for further much needed extensions. The honorary secretary of the committee is Mr. A. Goddard, Surveyors' Institution, 12, Great George Street, Westminster.

The Chemical Society of the University of Liverpool, which celebrates its twenty-first birthday this session, will hold its annual dinner on November 29th next, at the Midland Adelphi Hotel, Liverpool. Full particulars can be obtained from the Hon. Secretary, Mr. W. M. Inman.

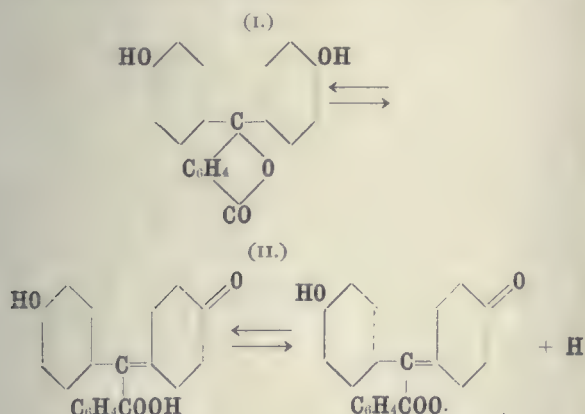
NOTES ON RECENT THEORY AND PRACTICE.

By HERBERT H. HODGSON, M.A., B.Sc., Ph.D.

IN a former series of these notes, a contribution by Waddell to the theory of indicators was mentioned. Briefly summarised, the contents of the latter were that, according to the ordinary theory of indicators, it is strange that methyl orange, a strong acid, should act towards weak acids as phenol phthalein, a weak acid, acts towards weak bases, and that the anomaly is removed if methyl orange is considered to be a weak base instead of a strong acid. A reply by Miller (*Chem. News*, August, 1913, p. 73) has been put forward, and his proposals will now be considered. Miller states that Waddell appears to have based his conclusions upon purely physico-chemical considerations, and omitted to pay sufficient attention to the chemical constitution of the indicator. The latter point is now generally accepted as almost fundamental, and many chemists supported by a considerable amount of chemical evidence strongly advocate the complementary character of the two views. Indicators are now regarded as pseudo acids or bases, and not actual ones, so that the undissociated molecule is really a mixture of one or more tautomeric forms in equilibrium, one of which only is capable of appreciable ionisation, *e.g.*, on the older theory of indicators phenol phthalein has the following behaviour:—



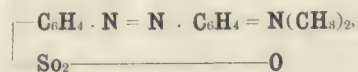
While on the later conception it is considered as showing the following equilibrium in solution:—



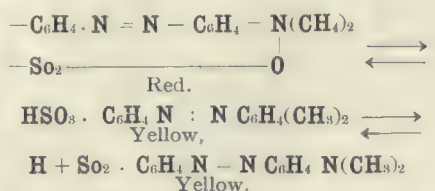
Configuration (I.) is the more stable and since the acid is very weak configuration (II.) and its ions are present to only a very small extent, so that the solution is colourless. Addition of bases (—OH ions) diminishes the concentration of the —H ions to such a degree that the colour due to configuration (II.) makes its appearance. In the case of the

colour formed by the action of concentrated ammonia being removed by the addition of ammonium salts, such as NH_4Cl , since —OH ions are present in relatively small amount and any addition of ammonium salts must diminish the concentration of the —OH ions to preserve equilibrium, the corresponding increase of H ions renders (I.) the stable configuration and the solution becomes colourless. That tautomerism exists may be supported by chemical evidence, for in the case of phenol phthalein the red colour is destroyed by addition of alcohol or acetone, and is undoubtedly due to an ionisation change. On the other hand, since the dry salts are red, there can be no question of ionisation.

In the case of an amphoteric indicator (*i.e.*, one which has both acidic and basic groupings in the molecule) such as methyl orange, the sodium salt is yellow while the free acid is violet, a circumstance pointing to a modification of the strongly acidic sulphuric group by the basic aminic group. Hewitt (*Analyst*, 1908, 33, 85) proposed an internal salt constitution to the free acid in the solid condition, or in acid solution, *e.g.*



a view independently put forward about the same time by Hantzsch (*Ber.*, 1908, 41, 1187; see also *Chemical World*, 1913, 11, 247). The aqueous solution will therefore be an equilibrium of the internal salt, the true dimethylamino-azobenzene sulphuric acid and its ions—



Addition of H ions diminishes dissociation and produces an internal quinonoid configuration, while the addition of even a weak base will remove H ions causing the yellow azoid ions to appear. In this case, too, chemical evidence supports the assumption of tautomerism, for the sodium salt has an orange yellow colour while the dry silver salt has the same violet colour as the free acid, and there can be no case of ionic dissociation here but an existence of tautomerism.

On Ostwald's dilution law a particular concentration of H ions is necessary for producing a colour change, and in the case of methyl orange this lies between 10^{-3} and 10^{-4} normal. The behaviour of this indicator towards a weak acid, such as acetic, may therefore be explained from the above concentration standpoint, since there is such a concentration of H ions in a weak acid like acetic which is very easily diminished by the addition of acetone, alcohol, or acetates, so that the unstable red internal quinonoid configuration gives place to the stable tautomeric azoid form, which at once ionises with production of the well-known yellow ion.

Waddell stated that he believed if almost dry

HCl were passed into an alcoholic solution of methyl orange the colour would still remain yellow. Miller carried out this experiment, using a solution of methyl orange in absolute alcohol, but found an immediate red coloration due to the fact that HCl being one of the strongest acids can assert its power of ionisation even in the presence of absolute alcohol. Thus it seems as if the present standpoint of the theory of indicators completely accords with the behaviour of methyl orange, and that Waddell's views regarding the yellow sodium salt of methyl orange as being undissociated in solution, and that the red colour produced by the addition of acids is due to the dissociated kations, are untenable.

The interesting discovery of a new oxide of carbon, $C_{12}O_9$, is reported by Meyer and Steiner. When mellitic acid is boiled under a reflux with much benzoyl chloride for six hours, it is dehydrated into the anhydride, separating in colourless crystals which are perfectly stable, sublime *in vacuo*, and are non-hygroscopic. If attempts are made to effect dehydration by the usual methods, the mellitic acid is either quite unattacked or yields a dicarboxylic acid, $C_{12}H_2O_{10}$. The oxide is practically insoluble in cold water, but reforms mellitic acid with warm. It gives characteristic colorations with various high boiling-point solvents, *e.g.*, with naphthalene it yields rose-red to bluish-red solutions, while with nitrobenzene a bluish-green solution is obtained.

A simple and convenient test for identifying small amounts of dyestuffs by oxidation with bromine has been described by Mathewson. A few c.c. of the dye solution is treated with bromine water, added drop by drop until about twice as much has been used as is required to destroy the colour. Some hydrazine sulphate solution is then added to take up the excess of bromine and finally an excess of sodium carbonate. A second test portion is treated in exactly the same way, except that a few drops of α -naphthol solution (10% in 50% alcohol) are added just before making alkaline with the carbonate. In general the dye should be in neutral or faintly acid solution. Hydrochloric acid, however, if not present in excessive amount, does not, as a rule, interfere. According to the colour changes observed the dyestuffs may be classified into the standard groups.

Since pure bromine is most essential for many operations involving the highest accuracy, it is of great interest to find that several new methods for obtaining the same have been proposed by Scott. One of these depends upon getting rid of iodate and iodide in potassium bromide, by boiling it with a little potassium metabisulphite and sulphuric acid, then twice adding saturated bromine water and distilling off the bromine, finally neutralising with potassium carbonate and evaporating to dryness. The bromide is then fused with potassium dichromate in quantity insufficient to decompose any chloride possibly present; the fused mass is decomposed by sulphuric acid, a little potassium permanganate being added to decompose organic matter. The halogen impurities are separated by

extracting the bromine with caustic soda, the chlorine being removed as chloride and the iodine as iodate.

In a paper at the eighth International Congress of Applied Chemistry, Professor W. Palmaer deals with the important question of phosphatic fertilisers. The following are at present produced in the order: acid phosphate, basic slag, bone meal, bicalcic phosphate, the first-named having an annual output amounting to about 10,000,000 tons. Bicalcic phosphate has so far only been produced in small quantities, *e.g.*, in 1910 only 5,000 tons were made in Germany and France respectively. At present this substance is only a by-product from the glue manufacture, where bone is soaked in dilute HCl, the glue substance constituting the residue, and the phosphate going into solution. The latter is precipitated by lime, thereby affording bicalcic phosphate. The method has the advantage of using a very poor and otherwise valueless raw phosphate provided there are not also present too many useless compounds, such as carbonate of lime. In the production of acid phosphate, on the other hand, a raw phosphate having a lower percentage than about 50% cannot be utilised, for owing to the admixture of gypsum the percentage of available phosphoric acid is only about half that of the raw phosphate's percentage of phosphoric acid, and consequently consideration of freight charges excludes the use of a low percentage raw material. However, it has been found that the price of HCl is too high for the adoption of this method, which in turn is due to the fact that the production of HCl according to the old methods entailed the sacrifice of H_2SO_4 . The case is different, however, if the acid is produced in such a way that a suitable salt, *e.g.*, perchlorate or chlorate of soda, is electrolysed with a diaphragm so that free acid is generated in the anode chamber and a solution of caustic alkali in the cathode compartment. The cost of the H_2SO_4 is here replaced by the cost of the electric power. The acid anode solution is allowed to work in a dissolving battery upon raw phosphate, in which process the phosphate is dissolved. Into the solution thus obtained is introduced the alkaline cathode solution, the whole being kept vigorously stirred until the liquid exhibits a slightly acid reaction for which about half the cathode solution is required. Bicalcic phosphate is ultimately produced as a finely crystalline precipitate, which is drained off by filtration and washed. Professor Palmaer quotes the work of Dr. von Feilitzen and Professor Söderbaum on the value of bicalcic phosphate as a fertiliser. The result of experiments in cultivation is that the citrate-soluble phosphoric acid in the bicalcic phosphate proves to possess the same fertilising value as the water-soluble phosphoric acid in the superphosphate, and consequently the same value as a trade product. That result might have been foreseen, inasmuch as it is probable that the superphosphate in the soil is rapidly transformed into bicalcic phosphate through the agency of the lime compounds present. Trials carried out by practical agriculturalists have given every satisfaction.

NOTES ON CHEMICAL ENGINEERING.

By J. W. HINCHLEY, A.R.S.M., WH.Sc.

CHAPTER V.

MIXING OPERATIONS.

ALTHOUGH mixing operations are continually being carried out in chemical factories, they are often most inefficiently performed. The mixing of solid materials presents difficulties which are often shirked rather than faced, with a resultant increased

permissible, the balls are omitted, and internal projecting vanes are provided to turn over the material and produce a satisfactory mixing. Where very fine grinding is required, together with absolute uniformity, as in the manufacture of high class plastic and other compositions, a dry mixing of the finely divided materials should always be made in the first instance, or small variations in composition will not be avoided.

The edge runner mill is often used for grinding and mixing at the same time, and its work is most satisfactory, although the output is small.

A simple mixer for dry or wet mixing where no attempt at grinding takes place is shown in Fig. 49. This represents the Vickers' mixer which is used in many manure works. The pans are usually 5 ft. in diameter, hold 1 ton of material, and take 5 or 6 H.P. for driving. The provision of a discharge valve at the base enables the workman to discharge and charge again without stopping the rotation of the paddle.

In another form of mixer the paddle rotates in a circle smaller than the pan, but travels round the pan by means of sun and planet gearing. In the

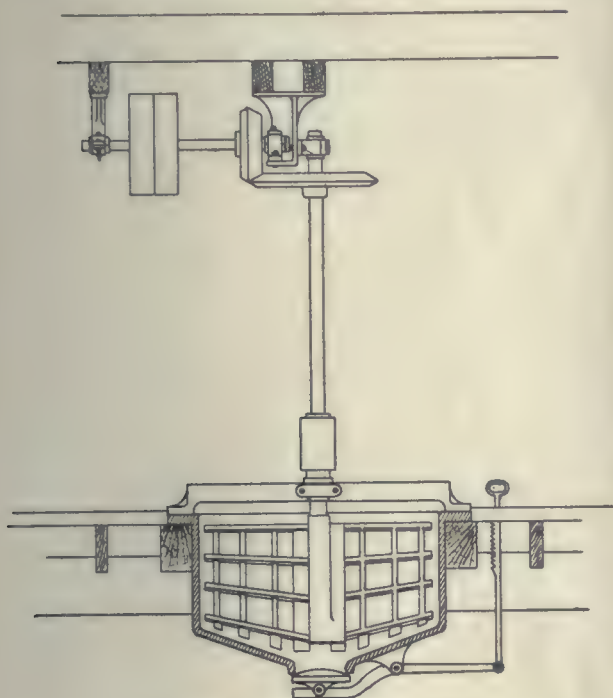


FIG. 49.—VICKERS' MIXER.

cost in later operations or lower quality and efficiency generally. The commercial loss is often far more serious than is usually imagined.

Uniform mixing of dry materials of different specific gravity or size is practically impossible. On this account materials are often mixed by being ground together without any previous attempt at mixing. In some cases a small percentage of liquid is added to increase the internal friction and thus tend to stop separation.

The ball mill is commonly used, both wet and dry, for simultaneous grinding and mixing. For batch-working, the closed mill is most convenient, and may be worked as a dry mill, provided that the liquid ingredients do not exceed 2%, or as a wet mill when they exceed 50%.

For continuous working the continuous ball mill or tube mill is often used, the ingredient being fed by simple measuring devices at one end of the mill, while the mixed and ground product leaves at the other. Where it is essential that coarse and fine material be mixed uniformly and no grinding is

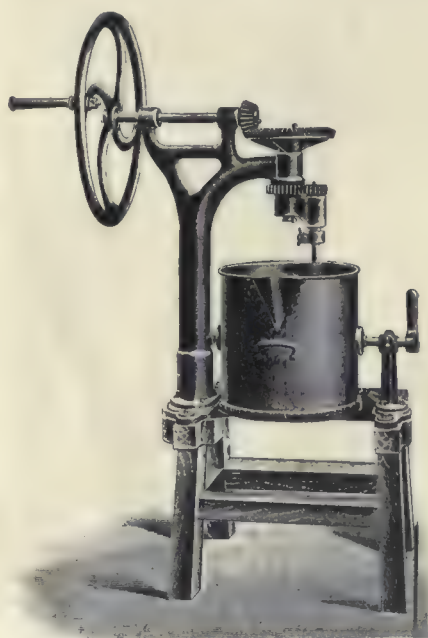


FIG. 50.—SUN AND PLANET MIXER.

machine shown in Fig. 50, the paddle may be removed after mixing and the pan turned on its trunnions for emptying. By the provision of a stoneware pan and paddle, this machine can be readily adapted for strong acid or alkali mixings. In some types of this machine, the pan and paddle are separated by means of a vertical screw or a rack and pinion, or by the provision of a long key-wayed spindle to the paddle.

The pans of these machines are often steam-jacketed when used for pastes, and in some cases the paddle is made hollow for the same purpose.

The ordinary pug mill of the clay worker is a crude mixing machine for plastic materials, and is

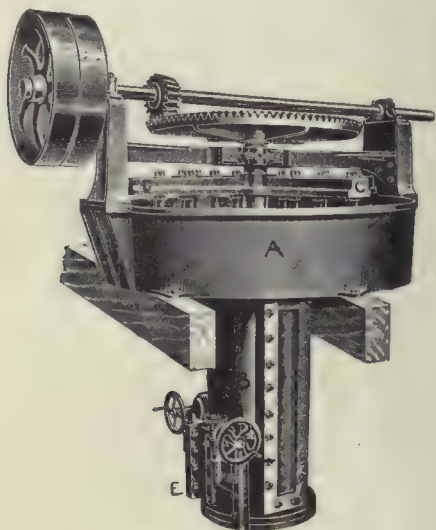


FIG. 51.—PUG MILL AND MIXER.

often provided as shown in Fig. 51, with a mixer for the dry clays used. The mixer consists of a flat pan A mounted above the pug mill B; the spindle of the pug mill, in addition to its pugging knives, carries arms C, provided with mixing blades D. The dry clays are continuously introduced near the periphery, and the requisite quantity of water added.

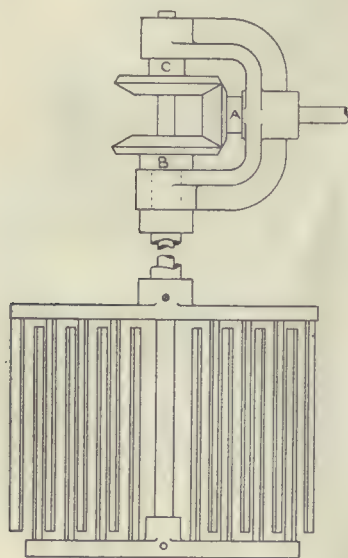


FIG. 52.—DOUBLE PADDLE.

The mixed and pugged clay is discharged from the adjustable outlet E near the base of the machine.

A pair of concentric paddles are often fitted to small mixers and increase considerably the efficiency of the machine. As shown in Fig. 52, the upper

paddle is fixed to a sleeve carrying the gear wheel B and the lower paddle to the spindle carrying the gear wheel C. On rotation of the gear wheel A, the paddles rotate in opposite directions. Such machines are also used, by rotation at a high speed, as whisking machines for the productions of air and liquid emulsions or for the formation of porous plastic and other masses.

Vertical mixers with two spindles are not often met with, except in factories producing emulsions,

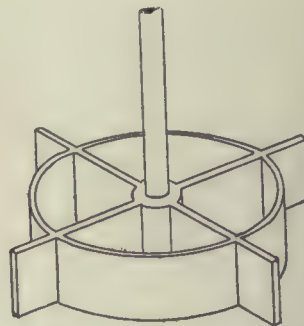


FIG. 53.—NIAGARA PADDLE.

margarine, etc., where they appear to be the standard machine.

The mixing paddle of vertical spindle mixers is made in many forms. In pug mills and simple types of mixers a series of projecting knife blades set at a slight angle seem effective; for fine powders with mixers having bowl-shaped containers, a narrow helical blade, which continually moves the material next the sides of the container, is excellent; with cylindrical containers, the Niagara paddle, Fig. 53, does excellent work if the depth of the material is not too great. This paddle is also used for maintaining solids in suspension in liquids, when the cross slats are often omitted and the circular part is

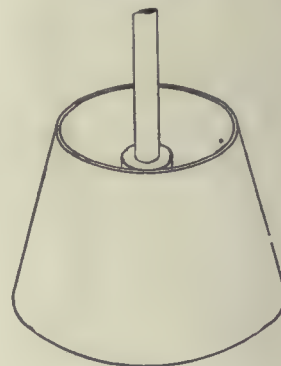


FIG. 54.—CONICAL PADDLE.

formed into a hollow frustrum of a cone tapering above or below. This paddle, Fig. 54, is the most efficient for mixing liquids. Paddles with projecting knives or wooden slats which pass between similar projections from the sides of the container are common.

Although the provision of a bearing for the paddle in contact with the mixture is not desirable, this

construction is generally adopted on grounds of economy. Such bearings usually consist of a vertical pin mounted on the base of the container, fitting into a recess at the end of the paddle spindle. This construction allows the material treated or grit to fall from the bearing rather than into it. With wooden paddles or spindles, the pin is made of a hard wood like *lignum vitæ*, working in a bearing

to act as mixers in a similar way; the trough is enlarged and the worm modified as in the "Gardner" machine for mixing.

Two spindle mixing machines are not common on account of their greater cost except for mixing plastic materials where single spindles obviously fail, by the mass moving as a whole. The "Universal" machine, Fig. 56, is a type of this class; the blades vary in shape according to the consistency and character of the material.

(To be continued.)

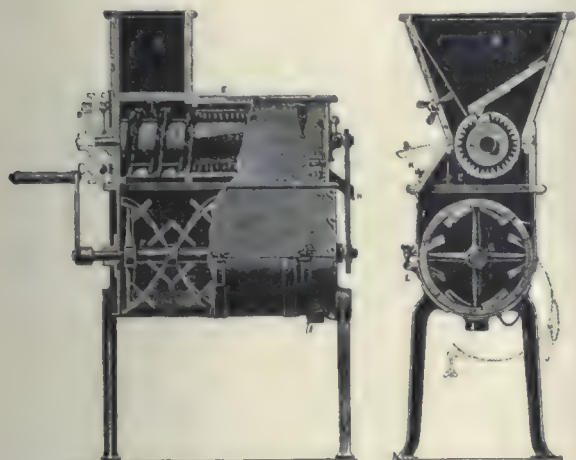


FIG. 55.—GARDNER MIXER.

of similar material let into the shaft. With metal paddles the pin is often conical. A thin disc of hard graphite or of fired steatite-clay composition is often inserted for lubricating purposes. A recess containing stiff grease or petroleum jelly is another method of lubricating, but if the vertical pressure is taken on a collar outside the container, lubrication of the footstep bearing may not be necessary.

Of mixing machines with horizontal spindles, the "Gardner," Fig. 55, is the best known. The paddle consists of a series of helical blades set in

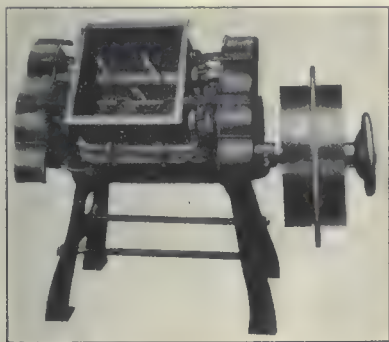


FIG. 56.—UNIVERSAL MIXER.

opposite directions, which on rotation throw the material backwards and forwards in a semi-cylindrical trough. A brush sifter BC is usually added to ensure the absence of lumps, and discharge is made by means of a sliding plate at I. For cleaning purposes the lower part of the mixer may be dropped by releasing the fly nuts at L.

Worm conveyors are often modified at one part

NOTES OF MEETINGS.

Institute of Chemistry.

November. "The Research Chemist in the Works, with Special Reference to the Textile Industry" Mr. W. P. Dreaper (second Lecture), at the Imperial College of Science and Technology.

Chemical Society.

November 6th and 20th, at 8.30 p.m.

Society of Chemical Industry.

LONDON SECTION.—November 3rd, at the rooms of the Chemical Society. Professor H. E. Armstrong, "Studies in Oxidation," IV., "Production of Oxygen by Electrolysis," "Peroxidation as determined by Platinum and Other Catalysts." Mr. R. G. Grimwood, "Analysis of Crude Glycerin by the International Standard Methods" "Determination of Organic Residue." B. J. Smart, "Abel Heat Test."

LIVERPOOL SECTION.—November 29th. Professor F. Haber, of Berlin, will deliver the Hurter Memorial Lecture.

MANCHESTER SECTION.—November 7th. Mr. J. Hubner, "Contribution to the History of Dyeing."

NEWCASTLE SECTION.—November 12th. Dr. J. E. Stead, "Some of the Alloys of Iron, Phosphorous and Carbon."

Society of Public Analysts.

November 5th, at the Chemical Society's rooms, at 8 p.m., when the following papers will be read: "The Preparation of Rubber for Analysis," by Leonard Archbutt; "The Examination of Commercial Gelatines in Reference to their Suitability for Paper-Making," by R. W. Sindall and W. Bacon; "Some Experiments on Chlorine Compounds of Ethane and Ethylene with special reference to their Application to Analytical Chemistry," by L. Gowing-Scopes; "The Detection and Estimation of Benzoic Acid in Milk and Cream," by Edward Hinks.

Biochemical Society.

November 12th, at 5.30 p.m., in the Physiological Laboratory, King's College, London.

Royal Photographic Society.

November 18th. Technical Meeting. "Testing Ordinary and Orthochromatic Plates for Comparative Speeds by Daylight," by W. B. Ferguson, K.C., M.A.

Institution of Civil Engineers.

November 4th, 11th, 18th and 25th, at 8 p.m. Ordinary Meetings.

Institution of Mechanical Engineers.

November 20th. General Meeting (in Manchester).
November 21st. General Meeting.

REVIEWS OF BOOKS.

"INDUSTRIAL CHEMISTRY." A Manual for the Student and Manufacturer. Edited by A. Rogers and A. B. Aubert. CONSTABLE & Co., LTD., London, 1912. Pages 854 + xiv, including Index. Chapters XLIII., with 340 Illustrations. Price 24/- net.

THIS work represents a successful attempt to present modern American practice in as confined a space as possible. Opening with a chapter on general processes, and one on materials used in construction, the question of water used for industrial purposes is considered at some length; then fuels, producer and gas, and power transmission. The manufacture of sulphuric, nitric, and hydrochloric acids is then dealt with. Other chapters are devoted to electro-chemical industries, cement, pottery, glass, white lead, paints, fertilisers, gas, oils, soaps, essential oils, sugar, starch, textiles, leather, etc.

It will be seen that this work covers a large field. It certainly contains a great deal of useful information in a handy form, and will be found of considerable interest to students and others in this country.

"AN INTRODUCTION TO MATHEMATICAL PHYSICS." By R. A. Houstoun. LONGMANS, GREEN & Co., London, 1912. Pages 199 + ix, including Index. Chapters VI. Price 6/- net.

With the increasing interest in mathematics which is taken by all chemical students, this work will have a special value. It is divided into six sections or chapters, which deal respectively with attraction, hydrodynamics, Fourier series and conduction of heat, wave motion, electro-magnetic theory and thermodynamics. It is intended as a class-book for mathematical students and a knowledge of the calculus, and of elementary dynamics and physics is assumed. Many examples are given, and the book gives evidence of thorough and careful preparation.

"ORGANIC CHEMISTRY." By J. F. Norris. HILL PUBLISHING Co., LTD., London, 1912. Pages 579 + vii, including Index. Chapters XXXI. Price 10/6 net.

This is an interesting text-book, and one which will obviously be received with interest in this country. It is claimed that it emphasises the fundamental principles of the science and is chiefly concerned with organic compounds which are of practical importance. The work is divided into thirty-one chapters, that on the metallo-organic compounds having a special interest. The book is well worth the attention of teachers and others interested in organic chemistry.

"THE CHEMISTRY OF DYEING." By J. K. Wood. GURNEY & JACKSON, London, 1913. Pages 79 + ii, including Index and Bibliography. Sections 3. Price 1/6 net.

This monography presents in an elementary

way the nature of the dyeing process as it is understood to-day. In the first section the chemical composition and properties of textile fibres are very briefly considered. Section II. dealing with dyes and their properties, and Section III. with the nature of dyeing processes is naturally the most important of the three. So far as it goes, this work is one of considerable interest, and will undoubtedly serve its purpose, which is to arouse a greater interest in the theoretical side of dyeing.

"METALLIC ALLOYS: Their Structure and Constitution." By G. H. Gulliver. Second Edition. CHARLES GRIFFIN & Co., LTD., London, 1913. Pages 409 + vi, including Index. Chapters XI., with 310 Illustrations. Price 10/6 net.

The rapid advance in the study of alloys makes the re-appearance of this book of special interest at the present juncture.

It is divided into eleven chapters which deal with investigation, physico-chemical equilibrium binary alloys, transformations which occur in solid metals and alloys. Structure of metals and alloys, the bronzes, brasses and other copper alloys, and alloys of iron. The final chapter is one of considerable interest as it deals with the microscope in engineering practice. The illustrations are particularly good, and the tables of references to standard works on each subject will be of great value to the student and chemist. This second edition has been greatly enlarged, and largely re-written. It should be in the hands of all those interested in metals and their working.

"LIQUID AIR, OXYGEN, NITROGEN." By Georges Claude. Translated by H. E. P. Cottrell. J. & A. CHURCHILL, London, 1913. Pages 418 + xxv. Chapters XIX., with 151 Illustrations. Price 18/- net.

The translation of this work will give the English chemist a chance of appreciating the work of Claude and others who have devoted their time to the commercial separation of the gaseous constituents of the air. The work is well illustrated, and deals with the liquefaction of gases, the commercial liquefaction of air, preservation and properties of liquid air, and the separation of air into its elements.

The future use of oxygen and nitrogen in industry is likely to develop. If the application of oxygen in smelting ever becomes a commercial possibility, its use may even become more important than that of nitrogen as used in the production of artificial fertilisers.

The work presents in an attractive form the remarkable advance which has taken place in the past, and indicates from the author's point of view the lines of future progress.

The translator has thought fit to follow almost

to the letter the original form of the French work. This is an experiment which might, in less experienced hands, have ended in disaster. In the case in review it has produced a book with an "atmosphere" which is not often met with in a work of this nature.

"TREATISE ON GENERAL AND INDUSTRIAL ORGANIC CHEMISTRY." By **Ettore Molinari.** Translated by **Thomas H. Pope.** J. & A. CHURCHILL, London, 1913. Pages 770 + viii, including Index. Divided into 3 Parts, with 506 Illustrations. Price 24/- net.

This volume deals with industrial organic chemistry on similar lines to those adopted in the first one, which covered inorganic chemistry. It again demonstrates the original outlook adopted by its Italian author. It is crowded with illustrations of the various manufacturing processes dealt with, which are too numerous to be mentioned individually. Generally, it is divided into three sections. The first one is called general, the second one deals with derivatives of methane, and the third section with cyclic compounds. The work contains information which can hardly be obtained in any other text-book. It contains useful statistics and, owing to its nature, gives the student considerable knowledge and a general idea of the many manufacturing operations involved in industrial organic chemistry.

"OXIDATIONS AND REDUCTIONS IN THE ANIMAL BODY." By **H. D. Dakin.** LONGMANS, GREEN & Co., London, 1912. Monographs on Biochemistry. Pages 135 + vi, including Bibliography and Index. Chapters VI. Price 4/- net.

This important monograph in this well-known series on biochemistry outlines what is at present known in connection with certain obscure reactions which occur in the animal system. Since the observations of Lavoisier, the attempts to follow up this subject have been many. Much remains to be accomplished, but this volume indicates in itself, and through the complete list of references given, the very material progress which has been achieved in this difficult research. This work will be found to be a valuable book of reference to those who wish to engage in this still somewhat obscure branch of investigation. This volume can therefore be recommended as an altogether satisfactory *résumé* of the present state of our knowledge in this direction.

"THE EXAMINATION OF WATERS AND WATER SUPPLIES." By **John C. Thresh.** Second Edition. J. & A. CHURCHILL, London, 1913. Pages 644 + xx, including Index and Appendix. Chapters XX., with 53 Illustrations. Price 18/- net.

This important work has gone to a second edition, in which many of the sections have been amplified. The work may be considered indispensable to those who would have information concerning the various sources of supply which may exist in any district. The second part is taken up with a general *résumé* of the different methods of examining water and equally important interpretation of the results obtained. This section is also concerned with the microscopical and biological examination of waters.

The work is suitably illustrated by a series of plates, and also contains many valuable tables. The standing and past experience of the author is a sufficient guarantee of its practical value to the general chemist.

"SECOND YEAR COURSE OF ORGANIC CHEMISTRY FOR TECHNICAL INSTITUTES." By **F. B. Thole.** METHUEN & Co., Ltd., London, 1912. Pages 186 + vii, including Index and Appendices. Chapters XX. Price 2/6.

This text-book forms the second part of a series of text-books on organic chemistry, and contains chapters dealing with the aromatic series, sulphonic acids, diazo compounds, phenols, etc. The facts are marshalled in a satisfactory manner, and this work will without doubt serve a distinctly useful purpose as an elementary text-book.

"ANNUAL TABLES OF CONSTANTS AND NUMERICAL DATA, CHEMICAL, PHYSICAL, AND TECHNOLOGICAL." Subject-matter in French. Vol. II. Pages 758 + xi. J. & A. CHURCHILL, London, 1913. Price, 28/6 net, cloth; 25/6 net, paper.

The second volume of this valuable and unique compilation exhibits many important improvements over the first one. Its general value consists in the easy method of reference adopted, and the satisfactory way in which it has been compiled by those who have undertaken the laborious work which has been entailed in its production.

BOOKS, ETC., RECEIVED.

"Theoretische Chemie vom Standpunkte der Avogadro'schen Regel und der Thermodynamik," by Walther Nernst. Seventh Edition. Ferdinand Enke, Stuttgart, 1913. Pages 828 + xvi, with Index. Divided into 4 Parts. Chapters XXXIII. and 58 Illustrations. Price M. 22.

"Experiments Arranged for Students in General Chemistry," by E. F. Smith and H. F. Keller. Shorter Course. P. Blakiston's Son & Co., Philadelphia, U.S.A., 1913. Pages 54. Divided into 2 Parts. Chapters XXII. with 12 Figures. Price 60 cents net.

"The Sugars and their Simple Derivatives," by John E. Mackenzie. Gurney & Jackson, London, 1913. Pages 242 + xiii, including Index. Chapters XX. with 17 Illustrations. Price 7/6 net.

"Industrial Organic Analysis," for the Use of Technical and Analytical Chemists and Students, by Paul S. Arup. J. & A. Churchill, London, 1913. Pages 340 + x, with Index. Chapters VIII., with 14 Illustrations. Price 7/6 net.

"Elements of Water Bacteriology," with special reference to Sanitary Water Analysis, by Samuel Cate Prescott and Charles-Edward Amory Winslow. Third Edition, re-written. Chapman & Hall, Ltd., London, 1913. Pages 318 + xii, including Index and Appendix. Chapters XII. Price 7/6 net.

"Bulletin of the Imperial Institute." Vol. XI., July-September, 1913, edited by the Director and Staff, and by other contributors. John Murray, London, 1913. Pages 550, with Illustrations and Tables. Price 2/6 net.

"The Commercial Trend of the Producer-Gas Power Plant in the United States," by R. H. Fernald. Bulletin 55, Bureau of Mines, Washington, U.S.A., 1913. Pages 92, with 1 Plate and 4 Figures.

PATENT RECORD.

Abstracts of recently published Specifications specially compiled by MR. JOHN E. RAWORTH, Chartered Patent Agent, Queen Anne's Chambers, Westminster, S.W.

7713. A. DE BACK. **Method of, and Apparatus for, Recovering Iron and Steel from Waste Enamelled Articles.**

639/13. W. M. BROTHERS. **Plaster of Paris.**

A process or method of preparing plaster of Paris from gypsum or other calcium sulphate consists in treating the material in a vacuum or partial vacuum whilst being subjected to a temperature sufficient to liberate the water of crystallisation.

22839/12. ACTIEN-GESELLSCHAFT FÜR ANILIN FABRIKATION. **Diazotisable Disazo-dyestuffs for Cotton.**

23164/12. FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & Co. **Selenocyanides.**

This process for producing selenocyanides of the anthraquinone series consists in the production of diazo-selenocyanides of the anthraquinone series and in the conversion of these compounds into selenocyanides by boiling.

24156/12. W. PAHL. **Caoutchouc.**

In a process for the coagulation of the latex of plants furnishing caoutchouc, the latex is atomised by carbonic acid gas and is intimately mixed therewith.

25582/12. E. JALOWETZ, E. RICHTER and A. SCHÜCKHER. **Brewing and Malting.**

A process for improving water for brewing and malting purposes is characterised by the water being heated in an open tank and strongly stirred, and thereupon freed from the precipitates by filtering or decanting.

25858/12. P. L. T. HEROULT. **Iron Treatment.**

A process for making high grade pig iron, in which the pig iron, which may contain a large amount of sulphur, as it comes in the liquid state from the blast furnace or cupola or mixer, is treated in a basic lined electric furnace in a non-oxidising atmosphere in contact with basic slag free from iron-oxide, so as to practically eliminate completely the sulphur without acting sensibly on the content of carbon.

12742/12. F. L. NATHAN, W. RINTOUL, and F. BAKER. **Explosives.**

A method of stabilising propellant explosives containing one or more nitric esters, consists in incorporating therein one or more substances which are non-volatile, contain an aromatic radicle capable of ready nitration by the products of decomposition of the nitric ester to a substance or substances having no deleterious action on nitric esters, and is or are capable of being homogeneously retained in the explosive in sufficient quantity for effective stabilisation.

12743/12. F. L. NATHAN, W. RINTOUL and F. BAKER. **Explosives.**

A method of stabilising propellant explosives containing one or more nitric esters, consists in incorporating therein one or more esters of substituted carbaminic acids containing one or more aromatic radicles.

12745/12. F. L. NATHAN, W. RINTOUL and F. BAKER. **Explosives.**

12746/12. F. L. NATHAN, W. RINTOUL and F. BAKER. **Explosives.**

13141/12. J. W. COBB. **Process for the Extraction of Ammonia and Sulphur Compounds from Gas.**

13282/12. P. SCHWARZKOPF, S. BURGSTALLER, and WOLFRAM-LABORATORIUM, DR. ING. P. SCHWARZKOPF, G.m.b.H. **Improvements in Processes for the Manufacture of Articles of Refractory Metals and Alloys.**

16493/12. C. STILL. **A Method of Distilling Benzol Hydrocarbons from Saturated Wash-oil or Benzolated Creosote.**

18723/12. L. DERSCHOW and F. GRASSES. **Soap.**

The improved soap has, in combination, a soap base, sawdust or other finely divided wood, and petroleum or the like hydrocarbon solvent.

18822/12. W. A. BEATTY. **Plastic Composition.**

The process of producing a plastic composition consists in incorporating a cellulose ester with a condensation product of a suitable ketone and suitable phenol in the presence of a solvent or mixture of solvents, and evaporating to a mass of the desired consistency.

19124/12. A. G. GREEN. **Production of Black Colouring Matters and their Employment in Dyeing and Calico Printing.**

19346/12. T. H. MARTYN. **Improvements in or Relating to the Saving or Recovery of Tin, Gold, and other Ores from Sand or other Ore-bearing Ground.**

19358/12. A. HERMANN. **Artificial Stone.**

A process for moulding plastic material, such as asbestos and cement mixed with water and eventually with other filling ingredients, in which the pressing process is effected by passing the mass continuously between two converging tracks which can move in a longitudinal direction, resisting flexion and, if necessary, draining off any superfluous or expressed water, the intermediate space between the tracks being closed laterally for the purpose of effecting the compression of the mass with a minimum of elongation.

19368/12. CHEMISCHE FABRIK "VAHRENWALD." **Solid Disinfectant.**

A process for the manufacture of solid disinfectants is characterised by a mixture of phenol or cresol, or similar homologues and sulphuric acid being caused to act on borax or oxide of zinc.

19452/12. T. A. BAYLISS and B. G. CLARK. **Aluminium Alloy.**

A malleable alloy, composed of aluminium, zinc and cadmium, consists mainly of aluminium. The ingredients are present between the limits of aluminium 80—99%, zinc 0.001—19.999%, and cadmium 0.001—10%.

19676/12. G. PETROFF. **An Improved Process for Treating and Refining Crude Petroleum, its Heavy Lubricating Distillates, Lubricating Mineral Oils, Paraffin and Ceresin.**

19847/12. J. S. WHITAKER and WETCARBONIZING, LTD. **Treatment of Peat.**

20180/12. P. MARINO. **Electrolytic Pickling of Metals.**

An electrolyte for use in electrolytic pickling baths consists of an aqueous solution of boron fluoride, sodium or potassium fluoride and tin fluoride.

20757/12. W. A. HALL. Sulphuretted Hydrogen.

A process for the manufacture of sulphuretted hydrogen from iron pyrites consists in subjecting the pyrites, while agitating the same, to the combined action of a reducing flame, which decomposes it without producing any appreciable amount of oxidation, and steam intended to furnish hydrogen to the sulphur and oxygen to the iron.

20759/12. W. A. HALL. Improvements in Furnaces for Decomposing Pyrites and Other Metallic Sulphides.**20760/12. W. A. HALL. Sulphur.**

The invention relates to a method of facilitating the mutual decomposition of sulphuretted hydrogen gas and sulphur dioxide gas by bringing a mixture of these gases into contact with highly-heated sulphur vapour.

21012/12. C. W. CHIFFY, W. JAGO and WOODLANDS, LTD. Bread.

A process of making bread consists in incorporating with the flour or dough before baking a small quantity of a mixture of a harmless persulphate, such as potassium persulphate, and a salt of sulphurous or thiosulphuric acid.

21073/12. A. FERNEACH and E. H. STRANGE. Acetone.

A mixture of acetone and the higher alcohols is produced simultaneously by treating sterilised carbohydrate containing materials with a culture of a bacillus of the type of the bacillus of Fitz at a temperature of between 25° C. and 40° C., the fermentation being carried out in the absence of air and the products recovered by distillation.

22048/12. F. TIEMANN. Purifying and Decolorising Sugar.

A process for the purification and decolorising of sugar solutions is characterised by the fact that the sugar solutions are treated with oxalates of heavy metals soluble in water, such as oxalate of tin.

ENGINEERING NOTES.

By R. J. DUNDERDALE, B.A. (CAMB.), A.M.I.C.E.

The British Association: Education.

PRINCIPAL GRIFFITHS, F.R.S., President of the section on Education, delivered the address on the subject of the section, and though some of what he said will not be news to anyone who has thought and enquired about the matter (especially in relation to technical education), still, some of his points will bear a certain emphasis.

He first remarked on what would seem to appear to a great many educationists, and even more specially to the parents among the working population, a truism, *i.e.*, that it is desirable to carry the education of everybody who is willing (or, rather, whose parents or employers are keen or willing) past the elementary stage; coupled with which, that it is undesirable to teach small classes of the few who do reach a fairly high standard with some sort of facility.

A proposition really more repellent to common sense would be hard to imagine, and anyone who, like the present writer, has had some experience in teaching in, say, one of the large London Polytechnics, will call to mind at once instances of well-intentioned and parent-revering youths, who are a misery and a nuisance at once to themselves, their parents, their classmates and their teachers.

One youth in the writer's mind was totally incapable of grasping the most elementary trigonometry, and seeing

that this is mainly concerned with definitions and identities, his mental state must have been analogous to that of a man in the physical world trying to run with a dislocated femur.

The true desire should be to carefully prune and weed classes in polytechnics and similar institutions the more advanced they become, so that only those who can really profit, and those who wish to pay themselves for their own education shall be allowed to continue. Class teachers could then impart more in a given time, with much less strain to themselves and probably to everyone else concerned.

Principal Griffiths, before preparing his address, elicited replies from a great many education authorities to a series of eleven questions propounded by him on elementary education, and in the *Times* of Friday, September 12th, where his address is printed, this interesting list and a summary of the answers will be found.

The address then went on to refer to character in elementary education.

Professor Armstrong, in moving a vote of thanks, strongly emphasised the point that all minds were not alike in calibre any more than all bodies in stature, and with this in view, we think that some of those who, controlling very large works, run or support classes for the technical advancement of their employees, should view with less dissatisfaction the numerical dwindling in the highest grade classes, provided the quality be high, and it is to those chemists and engineers that this note is chiefly addressed.

Locomotive to Run on Naphthaline.

There has lately been completed in France a locomotive about 19 ft. long and of about 18 tons over the driving axles, to run on this product.

The transmission is through an ærothermal transformer to the axles, giving a perfectly flexible drive, a power of recuperation on down-grades and increased power on hills.

Among the claims put forward on the locomotive's behalf are that it can be cheaply worked (about 2s. 10d. an hour at full load) where water is dirty, hard or scarce, and that owing to the lightness of its fuel and the smokelessness of its exhaust, it would be serviceable in time of war. Another claim which might be advanced is that it would be of use in danger building areas, as there should be no danger of flying sparks or a flash from a sudden "short," as in steam or electric locos.

The carburettor and melting tank are in one piece and jacketed with water at 100° C, and melting goes on in a uniform manner and temperature, which would not be the case were the exhaust employed for the purpose. This last item may be of interest to the direct paraffin carburettor enthusiasts, the amateurs among whom usually dream of exhaust heat to almost vaporise the paraffin either before or after the carburettor, apparently forgetting that without a very sensitive thermal governor of some sort, this arrangement would usually have a most inappropriate effect.

Needless to say, the locomotive mentioned is started on spirit.

By-product Coke Ovens and Economical Carbonization.

In the course of the last twelve months, something like fifty coking plants of the by-product type have been erected in this country, nearly all of which are equipped with complete tar, sulphate and benzol recovery plants. These together should yield about 10 million tons of coke, and as

the change in coking practice is all in this direction, for at least 20 million tons of metallurgical coke is required per annum, probably a great many more of these ovens and recovery plants will go up in the not very remote future.

Various speakers at the recent meeting of the British Association in Birmingham referred to the need of economical carbonization, and this point will doubtless be brought home to the public and manufacturers, if sufficiently hammered at.

It is very probable that there is a limit of some sort to human invention, and that in the lifetime of a great many now living the increasing price of various fuels will become a determining factor in the general cost of existence; and at present there is no sign, on the practical horizon at any rate, of any other means of obtaining a satisfactory motive power in those parts of the world which are not conveniently situated to a reasonably large local Niagara.

Professor Armstrong, in opening the debate on the proper utilisation of coal, laid stress on the present waste,

and suggested that in the not very distant future these islands (being provided with but few large heads of water) would be dependent for their motive power on alcohol.

An evil day, in fact, seems destined to arrive in three or four hundred years for those countries whose industries and prosperity depend on a heat motive power, and in an incomparably shorter time the man in the street will be able to feel the first swell of this storm.

The easiest and in every way the best method to gain a breathing space at present is undoubtedly by the careful coking and gasifying of our coal supply, with the concomitant adaptability to varying household needs and factory loads. Dr. Lessing pointed out that enough volatile matter polluted the air from factory and more especially house chimneys during the year to keep the British navy in oil fuel for the same period. As a very large proportion of this could be recovered by proper carbonization, this statement should make the dullest pause and think.

COMMERCIAL AND TRADE REVIEW.

CONSULAR REPORTS.

Chemical Trade of Leghorn.

In a report on the trade and commerce of Leghorn for 1912, Consul Carmichael states that the imports of carbonate of soda have again increased, but that the quantity imported from British sources shows no increase and is lower than it should be.

The trade in sulphate of copper, excepting that of local manufacture, has almost wholly returned into British hands. The proportion this year is 98% from British sources, as compared with 85% last year.

Chemical Manures on the Chinese Market.

Mr. W. P. Kerr, commercial attaché at Peking, states in his report on the foreign trade of China for the year 1912 that the value of manures imported rose from £79,739 to £107,899, a figure still far below the potential requirements of this vast agricultural country. There is obviously an opening for the introduction of chemical manures, and it is somewhat discouraging to see to what a comparatively slight extent the Chinese agriculturists have responded to the efforts made in recent years by importers to take advantage of this opening. The Chinese Government does

RETURN OF IMPORTS.

	1911.	£	1912.	£
Carbonate of soda (from all sources)	139,820 cwt.	33,561	153,540 cwt.	34,289
(British sources)	12,870 "	3,680	12,780 "	2,856
	or 9% of the total.		or 8% of the total.	
Sulphate of copper (from all sources)	4,735 tons.	90,916	5,100 tons.	120,097
(British sources)	4,018 "	88,713	5,000 "	118,652
	or 85% of the total.		or 98% of the total.	

RETURN OF PRINCIPAL ARTICLES OF EXPORT.

Boracic acid (to all destinations)	1,843 tons.	30,068	1,500 tons.	29,912
(to British destinations)	453 "	7,981	471 "	9,109
	or 25%.		or 31%.	
Borax (to all destinations)	53 "	875	78 "	1,248
(to British destinations)	19 "	254	6 "	101
	or 36%.		or 8%.	

RETURN OF IMPORTS AND EXPORTS OF CHEMICAL PRODUCTS, ETC.

Imports.—Chemical products, medicines, etc. ..	47,836 tons.	460,227	54,610 tons.	557,953
Exports.—Colours, dyeing and tanning materials, etc.	2,613 "	35,615	2,916 "	29,318

The details of the import trade in carbonate of soda and sulphate of copper are embodied in the above tables:—

nothing to help; indeed, in the case of nitrate of soda, Chinese authorities insist on retaining the obsolete classification of this material as war material.

The Trade in Fertiliser Raw Materials at Jacksonville.

Vice-consul Mucklow, at Jacksonville, Florida, reports on the trade of his district as follows: The largest import business is that of raw materials for the manufacture of fertilisers, which are imported in solid cargoes, nearly all of which come from Germany. There are six large factories on the river front, three of which include sulphuric acid plants, besides which the railway facilities cause considerable shipments to pass through this port for interior points.

Fertilisers in Bari.

Vice-consul Berner reports on the trade of Bari as follows: There is a growing demand for all sorts of artificial manure, especially phosphates, the importation of which has almost doubled in 1912. Unfortunately the majority of the Apulian farmers are still averse to any rational cultivation of the soil, and only a small *élite* has so far realised the beneficial effect of a regular and methodical fertilisation.

GENERAL NOTES.

Prospects for the Rosin Industry in Russia.

Notwithstanding the insistence of Mendeleff and other Russian scientists that Russian acicular trees yield as pure rosin in all respects as those of any other country, its production in Russia, in spite of the enormous reserves of the forests, has always been very limited. Russia might easily export rosin and compete with the United States and France, instead of importing it mostly from America, *via* Hamburg. A Russian writer, commenting on this peculiar situation in the *Viestnik Mylovareniya*, says the reason is that the Russian climate allows too short a time for collecting the material, so that it remains a cottage industry which, with its primitive methods, yields small quantities and inferior qualities. Now, however, it is claimed that Professor S. P. Lainoff, of the Moscow Imperial Technical College, has improved the new process of N. J. Kursanoff, which ensures profitable results. To supply Russia's home needs requires, he says, about 100 factories, which would have to be judiciously distributed in respect to forest reserves and their relation to consuming centres.

Artificial Silk Production.

Although reliable statistics regarding production and consumption of artificial silk in various countries are not available, there is little doubt that Germany would head the list in both cases. According to the *Manchester Guardian*, last year 268,000 kilos. of artificial silk were used in Crefeld alone, whereas only 3,500 kilos were consumed by Swiss manufacturers. The Lyons silk industry, however, appears to view the chemical product with some suspicion, the total value of the goods made from artificial silk last year being estimated at not more than 2,000,000 francs.

The German silk trade began to show increased interest in the employment of artificial silk in 1906, when the price was reduced from 20.22 marks per kilo. to 17.17 marks. Previously the high price and various defects in the product had prevented its application in the piece-goods trade. Considerable technical difficulties were met with by weavers, and after about two years most silk manufacturers abandoned the synthetic product. Improvements in the process of manufacture were made, which resulted in the production of an article suitable for weaving, and in 1910 the product

was again taken up, not only by piece-goods manufacturers, but also by those engaged in the velvet and plush trade. The former use chiefly the finer qualities, from 70 to 100 deniers, nitro-cellulose silk being almost exclusively employed. The velvet manufacturers take the coarser qualities, about 140 deniers, principally viscose silk. The latter is preferred owing to its brilliant appearance. During the past three years the price of nitro-cellulose silk has ranged between 11.75 marks and 14 marks per kilo., and that of viscose silk between 12 and 13 marks per kilo.

Tar Distillation.

A recently published paper on the distillation of tar in metallurgical works, by M. Gevers-Orban, of Liège, suggests that ironmasters and steel manufacturers may encroach upon the province of the tar distiller by utilising all the by-products of their coke plant, and where no plant exists in connection with the furnaces to instal one. Many of the Continental iron and steel makers already produce their own coke, although there are still a great many blast furnaces in this country which depend upon purchase for their supplies of fuel. Whether it would be suitable, and profitable, for iron and steel makers to deal with the by-products of coke making is, however, a totally different question. The business of the tar distiller is highly technical, and those who manage blast furnaces cannot be supposed to be acquainted with it. It does not seem very likely that the tar distillers will have to fear much competition from the metallurgical establishments.

Artificial Manure from Peat.

A cheap method of obtaining organic artificial manure was described by Professor W. A. Bottomley to the Agricultural Section of the British Association, the title of his paper being "The Effect of Soluble Humates on Nitrogen Fixation and Plant Growth"—the treatment of ordinary moss litter with bacteria, thus obtaining an organic manure, a ton of which Professor Bottomley claims to be worth more than 80 tons of ordinary farm manure—a remarkable discovery. It has been found, he says, that the insoluble humic acid present in large quantities in peat can be readily converted into soluble humate by the action of certain aerobic soil bacteria. Peat, after treatment with these organisms, is sterilised, and then inoculated with a culture of nitrogen-fixing organisms. This prepared peat can then be used for soil inoculation, either by direct application to the soil, or preparing from it a culture solution. Experiments made at Kew upon plants demonstrate the remarkable effect which this peat has on plant growth, and at Chelsea Physic Gardens a plot of radishes watered once with an extract of prepared peat gave an increase of 54% over another untreated plot. One of Professor Bottomley's points is that ordinary organic manure is getting scarcer (the substitution of motors for horse vehicles in London is a case in point), and peat may become a marketable substitute. Further experiments are to be made next year.

Cyanamide Industry in Germany.

The annual report of the American Cyanamide Co., of Tennessee, contains the following interesting remarks on the development of the cyanamide industry in Germany. Dr. Albert R. Frank, of Germany, one of the founders of the cyanamide industry, writes as follows: "The entire production of the German cyanamide factories has been sold, not only for the year 1913, but also for 1914. During the

autumn of last year and the spring of the current year about 52,000 tons were sold. Up to now further large sales have taken place and it would be an easy matter to sell considerably more if the material could be furnished by the factories. This notwithstanding the fact that the prices have consistently and permanently risen. The Bayerische Nitrogen Werke, of Trostberg, have increased their production from 14,000 to over 20,000 tons, and are building an addition to their power plant. The cyanamide works in Knapsack are enlarging their capacity by 5,000 tons to 21,000 tons."

New Continental Textilose Concern.

A company has recently been registered in Paris with a capital of 11,500,000 francs, which may be increased to 20,000,000 francs, to take over several European textilose concerns. The combination will include the English Textilose Manufacturing Co., Ltd., Manchester; the Manufacture Francaise de Textilose, Paris; the Manufacture Belge de Textilose, Brussels, and the firm of Fratelli Borghi, Milan. The style of the new undertaking is the Société de Textilos et Textiles. The German works engaged in the manufacture of textilose are being considerably enlarged. It is reported that another product made by a new patented process from paper yarn, and which is stated to have advantages over other similar products as a substitute for jute, will shortly be put on the market under the name of "Stranfa." There is not much information available regarding this latest product, but the textilose interests profess to have no fear of it as a competitor, asserting it to be only suitable for coarse goods.

Tanning Materials.

The demand for tanning extracts, especially in the United Kingdom is steadily increasing, and the extent to which this demand may be served by increased imports of tannin-yielding products from countries within the Empire is set forth in detail in the third quarterly number of the *Bulletin* of the Imperial Institute. Many of the products referred to are perhaps not rich enough in tannin to be worth exportation in the raw state as tanning materials, but they are suitable for local use. The summary includes results of examinations in the laboratories of the Institute of a large number of materials which either are new in respect of their industrial application, or are new in the sense that they are from countries which at present do not export commercial supplies of these materials. The samples examined and reported on came from the East Africa Protectorate, the Anglo-Egyptian Sudan, Northern and Southern Nigeria, Gold Coast, South Africa, Cyprus, Fiji, Ceylon, Hongkong and Tasmania.

Indian Duties on Perfumes.

According to the *Indian Trade Journal*, the duty on floral perfume water varies at different ports, and the Indian Government have approached the Government of Bombay with a view to introducing a uniform tariff throughout the whole country. The matter arose on account of a certain firm importing some floral water perfumes which they claimed did not contain alcohol. The collector of customs at Calcutta, however, caused an analysis to be made, and a small amount of alcohol was found to be present. Duty was therefore charged on the shipments as "perfumed spirits." The point for consideration was whether the presence of a practically negligible quantity of alcohol should bring a perfume within the category of "perfumed

spirits." The Indian Government were inclined to take a liberal view of the matter, considering that such preparations might be admitted at a lower rate of duty as "floral perfume waters." The matter, however, still remains in abeyance.

Glycerine Prices Advanced.

For the first time since November the official price of the Chemically Pure Glycerine Association has been altered, an advance of £5 per ton to £95 naked for 5-ton lots having been announced. As may be surmised from the recent even course of the market, this advance has not been brought about by anything in the nature of manipulation, but is due entirely to the demand threatening to outstrip the supply. During the year there have been a few struggles in the Continental market for crude glycerine, but the association has proved strong enough to control the situation. It was stated that the advancing tendency of the better classes of fats and oils has driven consumers to saponifiable material containing less glycerine, with the result that the output of this important by-product has been reduced. In addition, the demand for both dynamite and commercially pure qualities steadily expands, and does not yet appear to have reached its limit.

M. L.

MAGNETIC DRILLS AND CHUCKS.

It sometimes happens in chemical and other works that drilling operations have to be performed in confined spaces, as the only alternative to removing what may be a heavy article to the workshop itself.

Under such conditions the use of a so-called magnetic



FIG. 1.—MAGNETIC DRILL.

drill may be of distinct service in many cases, owing to the fact that the drill automatically attaches itself to the iron or steel surface. The nature of these drills will be sufficiently indicated by reference to Fig. 1, which represents the "Vulcan" magnetic drill and reamer, as manufactured by the Westminster Tool and Electric Co., of Suffolk House,

London, E.C. It is claimed that at least 50% (and in some extreme cases 70 to 80%) of the labour cost for drill work is saved. The movement of a small switch sets the electro-magnet in operation, and the drill is fixed firmly to the iron object ready for work. It is claimed that the entire process of moving the tool into position, drilling a hole in a steel plate, and preparing for the next operation need not take more than one minute. The drill itself is



FIG. 2.—DRILL IN OPERATION.

powerful, and is guaranteed to drill 1 in. diameter holes, $1\frac{1}{4}$ in. deep in mild steel per minute.

Such an apparatus weighs about 190 lbs., and the electrical power used on normal full load is $1\frac{1}{2}$ H.P. The magnets are adjustable, and in some cases castors are fitted, thus rendering the drill suitable for deck work. Fig. 2 shows the apparatus as it is actually used in practice.



FIG. 3.—MAGNETIC CHUCK.

A further extension of this principle is seen in the "Vulcan" magnetic chuck, which is illustrated in Fig. 3. This may take the place of the face plate on the lathe. This is particularly useful in grinding, or finishing washers, piston rings, flat steel strips, and similar articles with flat surfaces.

MARKET REPORTS.

LONDON.—The tendency towards a decline of the export trade in chemicals, which was first noticed a few months ago, has meanwhile become much more pronounced, while the imports have increased. The value of the exports of chemicals, drugs, dyes, etc., during September amounted to £1,625,981 against £1,777,336 during the same period of last year. The decrease was most pronounced in the case of potash compounds and soda compounds; the former showing a decrease from £26,399 to £20,420, and the latter from £193,484 to £157,484. The value of exports of bleaching powder receded from £19,250 to £12,989, and that of chemical manure from £392,629 to £367,736 (although the quantity was nearly the same as that exported in September, 1912). It is difficult to estimate how far this decrease was due to the unsatisfactory condition of the labour world at home, but although this might have acted unfavourably on the foreign trade, it may be assumed that the chief cause of the lessened demand from abroad was the financial stringency on the Continent.

The home section has also quieted down considerably, causing manufacturers and salesmen to be less confident of a continuation of the trade boom. The position of some of the leading industries of the country leaves very much to be desired. This applies particularly to different branches of the metal industries, some of which are suffering from an acute depression.

There has been a change for the worse in the fertiliser section of the market. Sulphate of ammonia has not maintained its strength, and the continued absence of demand from America acts as a damper on the hopes of the makers. As we have pointed out before in these columns, the production of sulphate of ammonia in this country as well as abroad is making rapid advances. The consumption will, therefore, have to increase correspondingly if it is to counteract this influence. The vigorous propaganda carried on by people interested in the progress of the industry may possibly stimulate the home demand, but this alone would barely be sufficient to bring about the desired result. The opening up of new markets abroad appears a more effective way of providing an outlet for the surplus production, although this is necessarily a difficult and slow task. The local price for 25% gray, prompt, has gone back to £12 7s. 6d. but for forward delivery a premium of 2s. 6d. to 5s. is still asked. Nitrate of soda is fairly steady at 11s. for ordinary and 11s. 6d. for refined quality. The prophesied rise of prices in consequence of the curtailment of production in Chile has not yet taken place, and the statistical position of the article seems weaker than a short time ago. The tar products section has experienced a partial revival, inasmuch as the demand for benzole has considerably improved. The home consumption for motor purposes is going up by leaps and bounds, and is now of much more importance than it was in the past. The export trade, too, is quite satisfactory, enabling the makers to obtain 1s. 2d. per gallon (90% quality). Pitch is quiet but fairly steady. There is no lack of inquiries, though actual business proves still rather disappointing. The home demand for road-making purposes has diminished with the advance of the season, while, at the same time, the production has increased. The shipping season has not opened up as yet, but makers are still confident that it is only a question of a very short time before Continental buyers will rush into the market. The price keeps steady at 45s. to 46s. 6d. Carbolic acid has reached a very low level, in fact, it seems quite probable that the producers will find the prices too low for a reason-

able profit, in which case a curtailment of production is likely. Purchases at the present figure appear fairly safe as a further reduction is quite improbable. 60% acid is obtainable at 1s. 0½d. per gallon.

MANCHESTER.—The exporters of heavy chemicals evince some anxiety as to the lessening of the demand from abroad. A fair average business is still being done, but a comparison with the splendid results of the last few months reveals a decided decline. Bleaching powder is offered rather freely at £5 5s. to £5 10s., caustic potash at £19 10s. to £21 10s., and alum loose, in lumps, at £6 2s. 6d. Sulphate of copper is affected by the irregularity of the metal prices. Buyers are looking for a reduction as soon as the metal market shows signs of a decline, making business very difficult. The nominal quotation for sulphate of copper is £24 for prompt, and £24 10s. for forward.

GLASGOW.—The lowering of the American tariff rates has been the subject of much discussion in Scotch trade circles. Leading firms do not, however, expect a very great benefit on the exports in chemicals to the United States. As regarded bichromates, a member of a Glasgow firm said that the manufacturers in America were cutting prices to such an extent that they had reached the lowest level on record. When the fight came to an end and the prices advanced again the effect of the reduced import duty might make itself felt. The demand for chemicals on the Glasgow market has been quiet, but prices remained steady.

FINANCIAL NOTES.

It is understood that Messrs. Lever Brothers are making a new issue of 500,000 "C" Preference shares of £1 each, which are to be offered at 21s. £1,000,000 of these Preference shares was issued at the same price in May.

The accounts of the Colonial Gas Association for the year ended June 30th show that, including the amount brought forward, the balance available for dividend, after deducting debenture interest and the interim dividend of 2%, allowing for depreciation, and adding £400 to reserve, is £5,795. A final dividend of 4½% is recommended, making 6½% for the year.

The net profits of the Sungei Kari (Sumatra) Rubber Estate for the year ended June 30th, after providing for 10% depreciation on buildings, etc., amounted to £10,898. A final dividend of 5% on the Ordinary shares is recommended making 10% for the year.

The profit of the Singapore Para Rubber Estates for the year ended June 30th last amounted to £21,297, out of which the directors propose to pay a dividend at the rate of 5%.

TRADE ITEMS.

MESSRS. R. WOLF, of 7, Laurence Pountney Hill, London, E.C., issue a leaflet with illustrations of their patent superheated steam locomobiles, which are claimed to be economical for electrical power stations, and other purposes. The tests on an 800 B.H.P. unit are said to have given a consumption of 106 lbs. of coal and a production of 906 lbs. of steam per brake horse-power. At the end of 1912 it is stated that 11,155 units were working in connection with ceramic, iron and metal working, lighting, paper, mining, sugar refining, and other industries, with a total output of over 1,000,000 H.P.

Messrs. Gallenkamp issue Section I., Part III., of their new catalogue which is specially compiled for works chemists, and industrial and technical laboratories. It contains particulars of special apparatus, such as calorimeters, polarimeters, balances, anemometers, and that for testing inflammable vapours, calculating rules, fusion and platinum resistance thermostats, polarimeters, etc.

The Fairbanks Co., of City Road, London, E.C., send particulars of their gun-metal and iron body steam valves, the seatings and discs of which can be reground when necessary.

The North Cornwall China Clay Co., Ltd., inform us through their managing director, that they wish to state that during the recent troubles in Mid-Cornwall, their pits and kilns were working continuously under extra pressure, and that they were able to keep their customers supplied over that difficult period, also that they are still working up to their full capacity.

SHARE LIST.

Name of Company.	October 24th.	September 24th.
Alby United Carbide	1 1/8	1 1/8
Ditto. Pref.	3 3/4	3 3/4
Associated Portland Cement. (10)	6 1/2	6 1/2
Ditto. Pref. (10)	8 1/2	8 1/2
Babcock-Wilcox. Ord.	2 1/2	3 1/2
Ditto. Pref.	1 1/8	1 1/8
Bell's United Asbestos	1 1/2	1 1/2
Bleachers' Association. Ord. ..	3 1/2	3 1/2
Ditto. Pref.	1 1/8	1 1/8
Borax Consolidated. Pfd. (5) ..	5 1/2	5 1/2
Ditto. Defd.	1 1/8	1 1/8
Ditto. Pref. (10)	11 1/2	11 1/2
Bradford Dyers	1 1/8	1 1/8
Ditto. Pref.	1 1/8	1 1/8
British Oil and Cake. Ord. ..	1 1/8	1 1/8
Brunner Mond. Ord.	4 1/2	4 1/2
Ditto. 7% Pref. (10)	14 1/2	15 1/2
Bryant and May. Pref.	2 1/8	2 1/8
Calico Printers	1 1/8	1 1/8
Ditto. Pref.	1 1/8	1 1/8
Castner Kellner	3 1/8	3 1/8
Commercial Salt. (2/-)	8/-	8/-
Crossley & Sons. (2)	1 1/2	1 1/2
Ditto. 5% Pref.	4 1/2	4 1/2
Eastman Kodak. (\$100)	530	570
Eley Brothers	1 1/2	1 1/2
Fraser and Chalmers. (£3)	1 1/2	1 1/2
Gas Light and Coke. (S.)	100	102
Ditto. 4% Pref. (S)	93	96
Greenwich Lino. (£)	3 1/2	3 1/2
Harrison and Crossfield. Pref. ..	1 1/8	1 1/8
Imperial Continental. (S)	163	168
Ditto. 3 1/2% Debenture (S) ..	83 1/2	85 1/2
India Rubber Co. (10)	13 1/4	14 1/4
International Salt	7/6	8/6
Ditto. Pref. (5/6 pd.)	2 1/8	2 1/8
Lever Brothers. 1st Pref. (10) ..	10 1/8	11 1/4
Lister & Co. Ord.	1 1/8	1 1/8
Mappin & Webb. Ord.	1 1/8	1 1/8
Neuchâtel Asphalt. (10/-)	9 1/2	9 1/2
Nobel Dynamite. (10)	12 1/2	17 1/2
Ditto. Bearer (10)	10 1/2	17 1/2
Ditto. 5% Pref. (10)	11	12
Pears, A. and F. Ord.	1 1/8	1 1/8
Ditto. 6% Pref. (10)	12	12
Price's Candle. (16)	30	38
Rosario. (5)	8 1/2	9 1/2
Salt Union. (4)	1 1/8	1 1/8
South Metropolitan 4% Stan-		
dard (S)	108	110
Ditto. 3% Debenture (S)	73	75
United Alkali. (10)	1 1/8	1 1/8
Ditto. Pref. (10)	8 1/2	8 1/2
Val de Travers	1 1/4	1 1/4



THE CHEMICAL WORLD

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Electrochemical Engineering.

A recent address before the Institution of Electrical Engineers is of special interest. As in the case of the modern chemist, the electrical engineer is often a very specialised person, and the result of this is seen in the direction of a very marked increase in salary offered in the case of central-station engineers and elsewhere. A similar movement is being witnessed in the case of many large firms employing chemists in this country. In the latter case this undoubtedly comes from a wish to have chemists who are really chemists; those who have been trained in methods of research, and not merely in analytical operations.

The greater number of electrical men who leave the universities and colleges find their way to manufacturing firms, and therefore have a first-hand knowledge of industrial application.

It will be remembered that the recently appointed secretary to the London University Appointments Board has deplored the fact that the best chemists do not enter the industrial world. They remain in the colleges to teach. This hermit-like action may be regarded as an error in policy from the general point of view of the position of the chemist and the influence he exerts on industry in this country.

Under the best conditions such a man may remain in, possibly, the institution in which he received his training in college chemistry, to pass this on to a succeeding generation of chemists, and to engage in academic research.

If he spends part of his time in the industrial world, he will obtain that experience in the ways of business which is claimed in the above address to be of such importance to the electrical engineer. If to the electrical engineer, why not to the chemist?

The future relationship between the electrical engineer and the chemist was also dealt with. It was claimed that electrical engineers should find a considerable field for their activities in the direction of what is called electrochemical engineering. *"It was to be hoped that this work would not be left in the hands of those more directly concerned with chemical problems."* It is evident that the chemist will have to see that he is properly

equipped for such work, or he may be driven out of the field.

The mechanical design of the plant is not the only important consideration. Progress is largely determined by other factors, and a greater knowledge of materials and their use in the electrical furnace. And while the electrical engineer is rightly concerned with the production of cheap power, and possibly the electrical conditions which obtain in the furnace, he is probably invading the province of the chemist if his work extends beyond this point. It is still in the hands of the chemist to determine whether he is willing to be ousted from this position without a struggle.

Why is it that the chemist so often plays second fiddle to the engineer in a works? It has been proved over and over again that such a position leads to interrupted progress, and is neither in the interests of the engineer, or the chemist. It is almost time that this position should be considered in greater detail.

Inflammable Fabrics.

The so-called Misdescription of Fabrics Act, which comes into operation on January 1st next, deals with the flannelette question and enacts that it is unlawful for any person to sell, expose, or have in his possession for sale, a textile fabric in any form to which is attributed the quality of non-inflammability, or safety from fire, unless such a fabric conforms to such standards of non-inflammability as may be prescribed by the Secretary of State in the Act. The fine for a first offence is £10, and in case of second or subsequent offence, £50.

The duty of enforcing the provisions of this Act rests with the local authorities, of whom are specially mentioned the City of London, councils of boroughs, and district and county councils. In the case of the London County Council, and subject to the approval of the Secretary of State, arrangements may be made with any metropolitan borough to act as agent for the London County Council, on such terms and conditions as may be agreed on. The expenses of the prosecution will be defrayed by the authorities, and all fines imposed will be paid to the local authority and carried to the credit of the fund out of

which the expenses incurred by the authority under this Act are defrayed.

This Act also applies to Scotland and Ireland, subject to certain modifications.

PAST AND FUTURE WORK OF THE CONDENSER TUBE CORROSION COMMITTEE.

THE Institute of Metals Corrosion Committee has now been at work for some three-and-half years.

Two reports have been published by Dr. G. D. Bengough, who has carried out his investigations in the Metallurgical Department of the University of Liverpool. The First Report, issued in January, 1911, and published in Vol. V. of the *Journal of the Institute of Metals*, was intended to give a general view of the knowledge as to the corrosion of non-ferrous metals both in its practical and scientific aspects, and is the most comprehensive survey of the subject that has yet been published. On the basis of this report the committee decided to initiate an experimental investigation of the cause or causes of the corrosion of condenser tubes in marine engines.

An appeal for funds was issued, and the response was sufficient to enable a two years' research to be undertaken, which formed the subject-matter of the Second Report to the committee presented at the Ghent meeting of the Institute of Metals held at the end of August in the present year.

Corrosion Resisting Tubes.—The experimental work has been carried out both in a special condenser and by means of laboratory experiments. The condenser plant was erected with the object of reproducing as accurately as possible the conditions to which condenser tubes are submitted in actual practice, and the laboratory experiments were designed to interpret the observations made with the larger apparatus, a procedure which has been signally successful in its results. In both cases it was found possible to observe and study "dezincification," which is the usual cause of the failure of tubes in practice. Tubes of four different compositions have been examined under strictly comparable conditions. The ordinary 70:30 tube of commerce has been shown to be far surpassed in resistance to dezincification by tubes containing 70% copper, 28% zinc, and 2% lead, and by those of "Admiralty" composition, *i.e.*, containing 70% copper, 29% zinc and 1% tin.

Muntz metal, 61% copper, 39% zinc, has been shown to be unsuitable for use as condenser tube material.

Great Importance of Temperature.—The influence of a variety of "deposits" and "particles" which have hitherto been supposed to cause localised dezincification has been shown to be of only secondary importance, and dezincification has been found to start and proceed rapidly in their absence. *In all cases the rapidity of the failure of the tubes was found to depend principally upon the temperature to which they were subjected.* If corrosion is to be prevented, or at any rate minimised as much as possible, *the temperature in the condenser must be kept low.*

Preliminary experiments have been made on the mode of action of electrochemical protection. This has been found to be intimately connected with the deposition of a continuous layer of calcium carbonate upon the inner surface of the tubes.

New Work.—The committee have met recently and having obtained sufficient funds to continue their investi-

gations for another two years they have planned a further scheme of work which is now well in hand. In deciding upon the lines of future investigation they have been careful to take into consideration a number of valuable suggestions and criticisms which have been made on the Second Report, both in the discussion at Ghent and in the comments of the technical press. The scheme includes a complete time-temperature survey of the conditions under which dezincification can take place and a more detailed study of the temperatures existing in their own and other condensers. Special attention will also be directed to the conditions under which electrochemical protection can be effectively maintained, and in this connection a comparative study of all the principal methods of holding tubes in tube-plates will be carried out. A systematic series of experiments will also be initiated with a set of tubes of a copper-aluminium alloy, from which specially interesting results are anticipated.

INSTITUTE OF CHEMISTRY LECTURES.

At a meeting of the Institute of Chemistry, held on the 26th ult., Mr. W. P. Dreaper gave his second lecture on "The Research Chemist in the Works, with Special Reference to the Textile Industry."

The need of a working knowledge of theory was further illustrated by reference to the application of the so-called "neutral salt reaction" in explaining the presence of free sulphuric acid in certain textile materials.

The evolution of a textile material from its original state was illustrated by the changes which had taken place in the manufacture of mourning crape since a weaver, some fifty years ago, passed a length of silk material and a fishing net through a pair of rollers.

The processes involved in the bleaching of cotton were explained, and illustrated in some detail; and the principles involved in dyeing, and printing and finishing fabrics were also considered from the chemist's point of view.

When the chemist had to translate laboratory experiments into full scale work, it was essential that he should be able to give the engineer some idea as to the nature of the machinery involved; or better still submit a design for the same. The chemist through his past training adopted a different method of attack to that of the engineer, and this alone justified his presence in a works. On occasion the chemist would retain control of certain operations after they had left the laboratory, and thus become involved in industrial operations. The chemist should have more say in the choice of raw materials. The South African Government still recommended the use of a "sheep dip" which reduced the value of the wool, and introduced considerable trouble in subsequent manufacture.

The relative position of the chemist and engineer was dealt with. It was pointed out that a rigidly chemical training was an insufficient equipment for the modern investigator. He must either find himself working over considerable periods in other directions, or abandoning investigation when it just became interesting and profitable. Given a suitable subject, everything depended upon attention to detail.

For the right man, properly trained, the textile industry offered a good opening, especially when the worker concerned himself with investigations of a general nature. The lecture was illustrated by a range of samples, photographs, and actual demonstration of hand-block and spray printing.

THE ALLOTROPY OF NITROGEN. I.—ACTIVE NITROGEN.

By THOMAS MARTIN LOWRY, D.Sc., F.C.S.

Nitrogen not an Inactive Element.—It has long been suspected that the inactivity of nitrogen gas might be due, not to the inherent inertness of the element, but rather to the extreme stability of the compound N_2 in which it is commonly known. The view that atomic nitrogen would be extremely active is justified both by the imperfect analogy of ozone and by the great instability of many compounds of nitrogen. Amongst these the chloride, described by

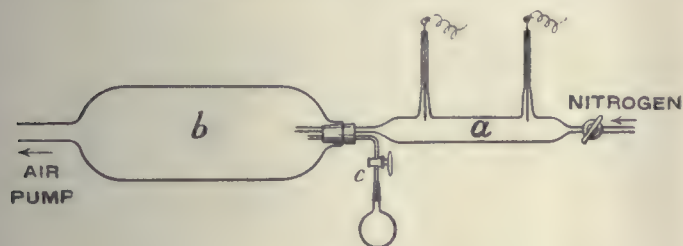


FIG. 1.

Ampère in a letter to Davy in 1812 (see "Davy's Works," 5, 391 and 398), and the iodide, discovered by Désormes and Clément in the same year, may be referred to specially as owing their violently-explosive character to the strong affinity of nitrogen for nitrogen. Earlier investigations had revealed the important part played by nitrogen in the detonation of "nitrum flammans" (NH_4NO_3) and "aurum fulminans" ($Au_2O_3, 2NH_3$), prototypes of the modern smokeless powders in which hydrogen and oxygen are attached with the help of nitrogen to opposite extremities of the same molecule. Later work has added the explosive diazo and triazo compounds to the list of substances which testify to the immense activity of nitrogen in its less stable complexes. Physiological chemistry has also provided ample evidence of the activity of nitrogen in the vital chemistry of plants and animals.

Electricity as an Agent for Decomposing the Nitrogen Molecule.—The number of chemical agents which are capable of decomposing the nitrogen molecule and producing nitrogen compounds is extremely small. Amongst the metals lithium, magnesium and calcium possess this power, whilst amongst the carbides those of calcium and barium are conspicuous for the readiness with which they are able to fix gaseous nitrogen, yielding calcium cyanamide in one case and barium cyanide in the other. In other cases the action of the chemical agent must be reinforced by the energy of an electric discharge before interaction can take place. It was thus that Priestley, in 1774, first succeeded, with the help of electric sparks, in "diminishing" air beyond the point to which it can be reduced by deoxidising agents. The sequel to this chance observation is found in Cavendish's experiments on air, in the

discovery of argon a century later by Rayleigh and Ramsay, and in contemporary processes for the fixation of nitrogen on a large commercial scale. The fact that nitrogen can be made to combine with hydrogen by sparking in presence of an acid was discovered by St. Claire Deville in 1865, but it is interesting to notice that the converse action (the decomposition of ammonia by sparking) had been discovered by Priestley nearly 100 years before.

Nitrogen rendered Active during an Electrical Discharge.—Two more modern observations are quoted by Professor Strutt to illustrate the activity that is conferred upon nitrogen by the electric discharge: (1) It is well known that phosphorus under ordinary conditions is not acted on by nitrogen. But for many years (since 1893) small quantities of phosphorus have been used to produce a high vacuum in incandescent electric lamps. In this case the discharge between the ends of the filaments appears to cause a combination between phosphorus vapour and nitrogen gas. (2) Threlfall, in 1893, observed the absorption of nitrogen when a jar discharge was passed through the gas at a low pressure in presence of mercury. The product was a compound (evidently an unstable nitride) which decomposed with a slight explosion when moderately heated.

Strutt's Discovery of Active Nitrogen.—The observations quoted above show that nitrogen may be made to undergo many chemical changes under the influence of an electric discharge, but they give no indication of the concrete existence of an active variety of the element analogous with ozone. This was discovered in 1911 by Professor Strutt in the course of his observations on the "after-glow" in vacuum tubes. The glow which appears in a

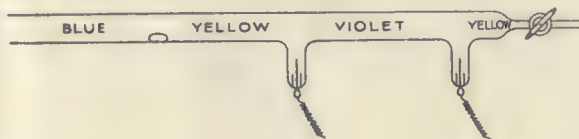


FIG. 2.

vacuum tube containing air was proved to be due to the interaction of nitric oxide with ozone. But a similar after-glow in pure nitrogen could not be explained in this way, and was proved to be due to the decay of a chemically active modification of the element, consisting probably of single atoms of nitrogen.

The apparatus used by Professor Strutt, in a recent discourse at the Royal Institution (February 28th, 1913), to illustrate the production and properties of active nitrogen is shown in Fig. 1. Nitrogen gas, under a pressure of a few millimetres

of mercury, passes rapidly through the tube *a* and is there acted on by a series of high-tension discharges from a Leyden jar. The gas issuing as a jet into the large vessel *b* is seen as "a whirling cloud of brilliant yellow light," the colour being totally different from that of the electric discharge in *a*.

Properties of Active Nitrogen.—Nitrogen which

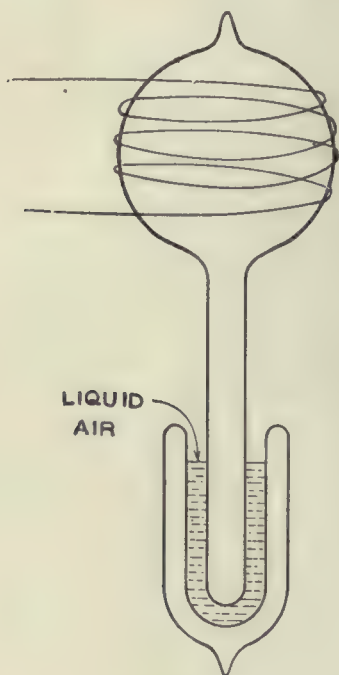


FIG. 3.

has been acted on by the electric discharge in this way is extremely active. It combines directly with sodium when this metal is heated just above its melting point in a current of the gas, the sodium spectrum being very strongly developed. Threlfall's explosive nitride is readily produced by the action of active nitrogen on warm mercury; the yellow colour of the after-glow is thereby changed to the characteristic green spectrum of the mercury arc, whilst the tube soon becomes obscured by a black deposit containing the nitride. Green and blue spectra are developed by admitting the vapours of thallic and stannic chlorides from the side-tubes *c* into the cylinder *b* of Fig. 1. Metallic spectra are also produced by the action of the gas on cadmium, magnesium, potassium, zinc and lead.

With iodine very beautiful colour effects are produced, the violet colour of the discharge changing to the yellow colour of the after-glow, Fig. 2, and then to a brilliant blue where the active nitrogen comes into contact with the vapour of the iodine. When active nitrogen is mixed with acetylene a lilac glow is produced, whilst chloroform gives an orange light; in each case the spectrum is that of cyanogen, although the relative intensities of the different components are not the same. By passing the products over a test-tube cooled with liquid air,

cyanogen compounds are condensed, which give the ordinary Prussian-blue tests. With carbon disulphide the products are a sulphide of nitrogen and carbon monosulphide.

Phosphorus absorbs the gas and at the same time is converted into red phosphorus. Quantitative experiments showed that 15.5 mg. = 12.2 c.c. were absorbed from 2,540 c.c. of nitrogen, *i.e.*, about 1 part in 210—a proportion that is comparable with the yield of ozone in an ozoniser.

The Decay of Active Nitrogen.—The activity conferred upon nitrogen gas by the action of the electric discharge is very transitory. Under the low pressures prevailing in the tube the free path of the particles is long, and only a short time is required for the dissociated atoms to recombine. The recombination is assisted in a remarkable way by cooling. This was shown with the apparatus of Fig. 3. A bulb containing nitrogen under low pressures is surrounded with a coil of wire through which a Leyden jar is constantly discharging; the currents induced in the gas result in the production of a brilliant yellow glow. When the neck of the bulb is cooled in liquid air a brilliant glow is seen, but this is of short duration, and on warming up again the glow is seen to have burnt itself out.

The remarkable effect of an oxidised copper surface in destroying the activity of the gas was shown by means of the apparatus of Fig. 4. The glow was excited as in Fig. 3, but was instantly extinguished when the oxidised copper wire was dropped into the bulb from the position shown by the dotted lines on the right-hand side of the diagram. In this case the activity of the nitrogen is destroyed without producing any increase of luminosity. The instantaneous disappearance of the after-glow provides a very striking experiment; the rapidity of the action is so great as to be almost incredible, except in face of an actual demonstration.

Professor Strutt's experiments are described in the following papers:—

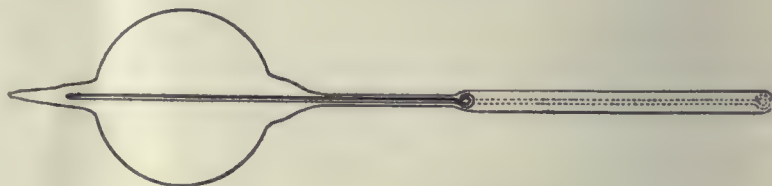


FIG. 4.

"A Chemically Active Modification of Nitrogen, Produced by the Electric Discharge": I., *Proc. Roy. Soc.*, 1911, 85, 219; II., *Proc. Roy. Soc.*, 1911, 86, 56; III., *Proc. Roy. Soc.*, 1912, 86, 262; IV., *Proc. Roy. Soc.*, 1912, 87, 179.

"Active Nitrogen," a discourse delivered at the Royal Institution on Friday, February 28th, 1913.

THE next meeting of the International Conference on the Structure of Matter will be held in three years' time at Brussels. *Nature* reports that, in order to extend the scope of the congress, the original members will retire automatically and their place be taken by new members.

THE TRANSMUTATION QUESTION.

By A. W. STEWART, D.Sc.

WHEN a discovery is made which revolutionises any field of science, it is often found that attention becomes so much concentrated upon the fresh data, that for a time the earlier work in the same line is to some extent left out of consideration. The transmutation question appears to offer an example of this; for interest at present is focussed upon the experiments in the laboratory; while some of the broader aspects of the problem are neglected, and but little attempt is made to view the subject as a connected whole. It seems not without interest to indicate the main outline of the older side of the transmutation question, and to endeavour to trace some connection between the phenomena of the laboratory and those which appear to be occurring on a far vaster scale among the celestial bodies.

In any inquiry into the possibility of transmuting one element into another, three interdependent questions suggest themselves. First: What is an element? Second: Is there any evidence tending to show that an element can be so modified as to become a different type of matter? Third: Can we voluntarily produce such an alteration in elementary matter with the means at our disposal?

Much verbal dexterity has been employed upon the definitions of elements; but for the present purpose it will be sufficient to define an element as a form of matter which passes unchanged through all our ordinary chemical reactions, and which manifests a certain characteristic spectrum under given conditions.

With regard to the second question, there are two lines of evidence open to us. In the first place, both radium and helium are elementary bodies according to the above definition; and it is known that the former gives rise to the latter in the course of its radioactive transformations. A change of one element into another thus appears to be possible. But this phenomenon is confined to one class of substances, the radioactive bodies; and in view of their peculiar properties, it might be urged that the case was not on all fours with that of the ordinary elementary forms of matter in which the radioactive properties are not so clearly marked. It is necessary therefore, to look further afield, and see if there are no other cases in which a change of one element into another can be surmised.

It will be admitted that since the majority of the elements are very stable forms of matter, a considerable amount of energy will be required to render them labile and capable of altering into other elementary substances; so that in seeking for environments where transmutation is probable, the energy factor must be borne in mind. Conditions must be sought under which energy at what we may term a high potential is being liberated. Kinetic energy, evidently, will not come into play; for the whole of the planets in the solar system are endowed

with it, yet there is not much evidence of transmutation on a large scale upon the surface of the earth. The most likely types of energy for the present purpose are heat, light, or magneto-electric forces; for we know that any of these can play a part in the interactions of the elements during chemical reactions. The suggestion of heat and light leads to a consideration of the stars and nebulae as possible centres of elementary transmutation; for clearly in solar or stellar atmospheres, there are temperatures far above any which can be attained on the surface of the earth.

It has been found, that by means of the spectroscope it is possible to gauge roughly the relative temperatures of heated substances. A solid body, when its temperature is raised, gives out a continuous spectrum which extends from the heat ray region down towards the ultra-violet; and as the temperature of the substance is elevated, the continuous spectrum tends to become extended further and further into the ultra-violet. Thus, if one substance gives out a short continuous spectrum, while a second body yields a much longer one, we are justified in concluding that the first substance is not at such a high temperature as the second one. Using methods such as this, Huggins, Lockyer and others, have classified the stars in the following way. Beginning with the nebulae in their earlier stages of existence, it is found that their spectra are comparatively simple, being composed of a few lines which include the hydrogen line; and in addition to it the lines characteristic of helium often make their appearance in older nebulae which have got over their first stages of existence. When the nebulae have cooled and condensed into the form of stars, the spectra become more complex; and the complexity appears to increase as the process of cooling advances. Thus there are stars of what is termed the helium type, which contain hydrogen, helium, oxygen, nitrogen and magnesium; the Sirian stars show the presence of iron; the sun, belonging to the third type, exhibits a very complex spectrum, proving the presence of a large number of metallic elements; the Antarian stars appear to contain titanium in proportions greater than are found in the sun; while, finally, in the coolest series of stars, the spectrum of carbon is developed and the stars are red and faint in their appearance.

These data appear to indicate that there is little connection between the compositions of the stars and nebulae; for the stars are much more complex than the nebular masses. Yet, as is known, the nebulae are actually very intimately related to the stars; for several of the new stars which make their appearance are actually nebulous in their character.

Various hypotheses have been suggested to explain the origin of novae; the collision of two stars; the disruption of two stars owing to tremendous

tidal disturbances on their surfaces when they draw near to one another ; or violent volcanic eruptions due to the same cause. In any case, the birth of a nova evidently takes place under conditions where thermal energy is liberated on a vast scale ; and in view of the sudden appearance of masses of very simple elements from which the more complex elementary bodies of higher atomic weight are absent, it seems only reasonable to conclude that under the stress of the conditions, some of the more complex elements have disintegrated into others of lower atomic weight. But there is another side to the problem. The simple elements of the nebula must be the parents of the more complex elements which are found present when the nebula condenses into a star ; and the star mass, in cooling, produces more and more complex types of elementary matter. Thus on the one hand, there appears to be a disintegration of elements when a star flashes into nebular form ; while on the other, there appears to be a process of elemental synthesis taking place as the nebula condenses into stellar shape and cools down.

At this point, it might be possible to draw a very rough parallel between the stellar evolution and disintegration of the elements and the experiments which have been carried out in terrestrial laboratories. The stars, in their transformation into nebulae, become the foci of vast liberations of heat ; for much of their kinetic energy is transformed into thermal energy under such circumstances. Thus the conditions which accompany the celestial transmutation on the analytic side, appear to be violent shocks, transformations of kinetic into thermal energy, great local rise of temperature and probably also some electrical

disturbances. Precisely similar conditions, on a very minute scale, must also be found when a solution of niton is allowed to undergo radioactive decay. The kinetic energy of the alpha particles is transformed into thermal energy ; local rises of temperature in a marked degree must occur owing to atomic collisions ; and the electrical disturbances due to the beta and gamma rays, will serve to parallel the electrical forces at work in the birth of novae. Any complex element which is brought into such a focus of disruption might be expected to break down into simpler bodies.

Turning to the nebulae, where the process of elemental synthesis is going on, the conditions are very different. Here there is a volume of gas, tenuous and widespread through space, so that it must be under very low pressures. Through this mass electrical storms will be playing ; for we find these phenomena even in the sun ; and it seems probable that such magnetic and electrical disturbances will have even more scope in the nebular masses. Thus the nebular conditions (a mass of very tenuous gas continually shaken by electrical phenomena) find their parallel in the vacuum tubes of the laboratory through which the cathode discharge is passed.

It is much too soon to venture definite assertions in such a field ; for astrophysics has still many gaps which will have to be closed before many of its hypotheses can be said to be completely acceptable ; yet it seems not without interest to find that an apparent parallelism can be traced between two sets of phenomena which at first sight appear to have nothing whatever in common.

KETO-ENOL ISOMERISM.

By ARTHUR CLAYTON, D.Sc., A.R.C.S.

It has been known for many years that compounds containing the group $\text{CO} \cdot \text{CH}_2 \cdot \text{CO}$ behave as though a hydrogen atom migrated to one of the oxygen atoms, with the result that the group assumes the enolic form $\text{C}(\text{OH}) : \text{CH} \cdot \text{CO}$, and it has been recognised that compounds of the type under consideration consist of a mixture of the two forms in equilibrium with each other. Only during the last few years, however, have the problems presented by such compounds been attacked with any marked degree of success. The subject has been approached by various chemists from different standpoints ; thus whilst some investigators have been engaged in elaborating methods for the estimation of the proportion of enol to ketone in equilibrium mixtures, others have devoted themselves to the actual separation of the two forms. Again, highly significant results have been obtained by the employment of the spectroscope, thus adding one more triumph to the long list of conquests achieved by this invaluable instrument.

Now it is apparent that in investigating the

phenomenon of keto-enol isomerism, the estimation of the proportion of enol or ketone at any moment is a matter of the greatest importance, for directly this estimation can be made, it becomes possible to trace the action of external agents, such as heat or solvents. Several methods are now available for the purpose of making this determination, and of these the most important are refractometric analysis, the spectroscopic method, which has been employed with great success by Hantzsch, and the method of bromination elaborated by Meyer.

The refractometer is found to give eminently satisfactory results, and possesses the very great advantage that it does not involve the addition of any chemical reagent to the substance under examination. It has been found that many classes of compounds catalytically alter the proportion of enol to ketone when added to an equilibrium mixture ; even impurities emanating from glass vessels produce this change to a marked extent.

The bromination method is based on the facts that enols react very rapidly with bromine, giving

rise to brominated ketones, and that the latter compounds may be quantitatively reduced by hydriodic acid, iodine being liberated. Accordingly, in order to determine the quantity of enol present in the equilibrium mixture, a cold solution of the latter is mixed with an alcoholic solution of bromine, β -naphthol being immediately added to remove excess of this halogen; potassium iodide is then added and the iodine liberated is estimated by the usual process of titration. The chief source of error in this method is the transformation of the ketone into the enol after the latter has been removed from the equilibrium mixture by conversion into a bromo-ketone. Owing, however, to the rapidity with which the estimation can be performed, Meyer considers that the error does not exceed $\frac{1}{2}\%$.

Another method which has been employed depends on the fact that the colour developed when an aqueous solution of ferric chloride is added to enols attains a maximum intensity when the enol and the reagent are present in equimolecular proportions. Hence it is only necessary to run a solution of ferric chloride of known strength into the equilibrium mixture, noting the point at which the intensity of the colour reaches a maximum. From the volume of the solution used the quantity of enol present is calculated. Unfortunately this method is marred by the fact that ferric chloride acts as a catalyst, rapidly increasing the proportion of enol.

The foregoing methods of analysis have made it a comparatively easy matter to estimate the two forms present in equilibrium mixtures, and, therefore, to determine the rate of change of one form into the other. It has been found that this rate of change becomes very small at low temperatures, and Knorr has made logical use of this fact by utilising refrigeration for the separation of the enol from the ketone. These forms have actually been obtained pure and distinct from each other in the notable cases of ethyl acetoacetate, methyl benzoylacetate, acetylacetone, and anthranol; and these achievements must be regarded as a triumph in the history of keto-enol isomerism.

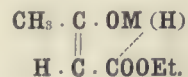
It is interesting to note that equilibrium mixtures cannot exist in the solid form, for if the substance is solidified by cooling, it gradually assumes either the purely enolic or ketonic condition; on melting, the equilibrium is again more or less rapidly established. This is contrary to views generally held until a year or two ago, for it had previously been considered that the balance between the two forms was maintained in the solid as well as in the liquid state.

The influence of solvents on the proportion of enol to ketone in equilibrium mixtures is very marked; thus methyl benzoate is enolised to the extent of 0.8% in water, 13.4 in methyl alcohol, 15.3 in chloroform, 69 in hexane, and 16.7 when molten. These figures show how easy it is to shift the point of equilibrium in compounds exhibiting keto-enol isomerism.

Perhaps the most remarkable and interesting point in connection with compounds containing the $\text{CO} \cdot \text{CH}_2 \cdot \text{CO}$ group, is the well-known fact that one

of the hydrogen atoms is acidic, well-defined series of salts being known. These salts are very peculiar in that whilst those of the more positive metals have the metallic atom joined to oxygen in the usual manner, others appear to have the metal attached to carbon. The latter salts are not ionised in solution, and are remarkably stable towards heat, often being distillable at ordinary pressures without decomposition; this class of salt is yielded by the less positive metals. Recent experiments have shown that there is no sharp line of division between the two classes of salts, and no explanation of the observed peculiarities appears to have been given.

The recent spectroscopic comparison of ethyl acetoacetate and its derivatives and salts in a number of different solvents has brought to light some very important evidence as to the constitution of these compounds. It is concluded that the selective absorption observed in solutions of the salts is due, not to the enolic modification, nor to an oscillation between the enolic and ketonic states, but to the existence of a new phase, called the *aci*-form. This conclusion was arrived at from the fact that, although enolisation of ethyl acetoacetate may take place to varying extents in different solvents, the absorption of the solution is never selective, whilst, on the other hand, the dissolved alkali salts always absorb selectively. Hantzsch considers that the *aci*-form differs from the enolic form in that there is a subsidiary bond between the metal (or hydrogen atom) and the carbonyl group of the COOEt complex, as shown by the formula



Whether this explanation is correct or not it is too early yet to say, but there is strong evidence in its favour. It should be noted that the *aci*-form cannot exist to more than a minute extent in ethyl acetoacetate itself or its solutions, but becomes vastly augmented in solutions of the salts.

From the foregoing it will be seen that the phenomenon of keto-enol isomerism has now been fairly closely investigated, but the subject still presents many avenues for useful research. Many years may be expected to elapse before the investigation of keto-enol isomerism will be regarded as a work completed. In fact, there are scarcely any chemical problems answered so completely that it is safe to append the gratifying letters Q.E.D. Only too often have chemists had to obliterate this sign of a task performed, and seek in wiser mood for some more impeccable solution.

Electrolytic Alkali.—A recent discussion before the Society of Chemical Industry brought out the need for further work in this country in this direction, Professor Donnan claiming that it was a question of the present rather than the future—that English manufacturers might find that instead of preparing for the future it might be their lot to mourn for the past. The recent Billiter-Leykam cell was described, and working costs given for the chief systems in work to-day.

CHEMICAL INDUSTRIES.

A Monthly Review of the Progress of Technical Chemistry.

THE INCREASE OF PLANT FOOD IN SOILS.

By C. T. GIMINGHAM, F.I.C.

IN continuation of their notable work on the partial sterilisation of soils, Russell and Hutchinson have published, in a recent number of the *Journal of Agricultural Science*, 5, 152, a detailed paper on "The Limitation of Bacterial Numbers in Normal Soils and its Consequences." It will be remembered that in their earlier paper (*Journal of Agricultural Science*, 3, 111), the authors recorded the experiments which led them to their theory that normal soils contain some factor limiting the numbers of the bacteria which are primarily responsible for the production of plant food. This detrimental factor, provisionally identified with the larger organisms (protozoa) present, killed by heat or by the application of antiseptics to the soil, treatments which, after a preliminary check, result in an enormous increase in the numbers of bacteria, and consequently in the production of plant food. The later paper confirms and extends these observations, affording conclusive evidence that the bacterial numbers in a soil at any time actually represent an equilibrium set up by the result of the interaction of the bacteria and the larger organisms.

One or two objections to this view may first be considered.

It has been suggested that the presence of bacterio-toxins in the soil would account for the results. No evidence for the existence of such toxins could be obtained; and moreover, there is no accumulation of the harmful factor in partially sterilised soils where great numbers of bacteria are active, as there would presumably be if a toxin is concerned. Once the factor is removed, it does not reappear without re-introduction from unsterilised soil.

Another possible view is that the bacterial population after partial sterilisation possesses greater powers of plant food production. It has been shown, however, that the increased efficiency is due simply to increased numbers, and that the activity of individual species is actually lessened. On inoculating a little of the untreated soil into the partially sterilised soil, the numbers of bacteria reached are greater and the amount of decomposition effected is more than when the simplified flora of the partially sterilised soil develops by itself. (In this experiment the detrimental organisms introduced with the inoculating material are presumably too few to have their effect on the bacteria until later, and the check which does eventually set in is too late to affect the rate of decomposition.)

It is true that the investigation of the protozoa of the soil is not yet sufficiently complete to allow of the precise identification of the harmful factor, but there can be no doubt that it is *living*, and the assumption that it is the active soil protozoa fits in with all the known facts. Indeed, no exception has been found to the statement: "Whenever the ciliates and amœbæ are killed, we invariably find that the detrimental factor is extinguished; whenever the detrimental factor is not extinguished, the protozoa also are not killed."

Russell and Hutchinson further show that the numbers

of bacteria in the soil do not depend, as would be expected, on such soil conditions as the temperature or the water supply. From the figures given in the accompanying table, it will be seen that the numbers of bacteria in the untreated soil sometimes rise, sometimes fall, and are sometimes unaffected by a rise of temperature. On the other hand, in the toluene-d soil (*i.e.*, when the interfering factor is removed), the numbers are affected fairly regularly.

TABLE.

Soil containing 16% water, 0.37% N, 0.57% CaCO_3
and losing 11.05% on ignition.
Millions of bacteria per gram of dry soil.

Temperature, °C.	At Start.	Untreated Soil.			At Start.	Soil Treated with Toluene.		
		After 6 days.	After 20 days.	After 44 days.		After 6 days.	After 20 days.	After 44 days.
5°—12°	53	58	52	121	13	11	30	76
20°	53	58	82	46	13	54	92	125
30°	53	49	25	24	13	60	88	87
40°	53	7	9	9	13	43	49	7
50°	53	1	13	1	13	2	10	1.5

The same kind of results were obtained by varying the moisture content of the soil; and it is difficult to account for these observations except on the theory that other organisms are present in the untreated soil detrimental to the bacteria, and affected by changes of temperature and humidity in a similar manner.

A great many new data have also been obtained relating to the connection between soil productiveness and the increased numbers of bacteria brought about by partial sterilisation. It is now found that the relationship between the increases in the amount of ammonia produced in the soil and the increased numbers of bacteria does not hold beyond a certain limit, which is determined by the amount of ammonia and nitrate accumulated. If ammonia and nitrate are present only in small amount, partial sterilisation (by antiseptics) brings about an increase of ammonia corresponding to the bacterial numbers; if, on the other hand, the soil contains much ammonia and nitrate, there may still be the large increase in numbers of bacteria, but it is not followed by increased production of ammonia. That the accumulation of ammonia (and to a less extent, of nitrate) is the direct cause of this falling off, can be shown by the addition of ammonium sulphate (or sodium nitrate) to a partially sterilised soil when the rate of production of ammonia falls almost to that in the untreated soil.

The case is rather different when sterilisation is effected by heat. There is then a certain amount of direct decomposition of organic matter, and other disturbing factors come in. The conclusion is reached that both in soils treated with antiseptics and in soils heated to 55°—60° C., there is a direct relationship between bacterial numbers and the amount of decomposition; but that no such relationship holds in the case of soils heated to 100° C.

In a later paper (*Journal of Agricultural Science*, 5, 320), Hutchinson considers the action of caustic lime on the soil. The improvements following the addition of lime to the soil have, of course, long been known, and a number of ways in which the action takes place can be specified. In addition to these, however, a further mode of action is here discussed. It is shown that when quicklime is applied in considerable quantities to the soil, its antiseptic properties are sufficient to kill the larger forms of protozoa, the effect being a partial sterilisation precisely comparable to that due to volatile antiseptics or to heat. Increased numbers of bacteria and a corresponding increased production of plant food in the soil occur as soon as all the calcium oxide is converted into carbonate. In addition to this, caustic lime causes a very considerable decomposition of the organic matter of the soil, the products of which are probably available as food for the bacteria.

FOOD ADULTERATION IN FRANCE.

By CECIL W. WOOD.

PUBLIC attention is being drawn to the further need of reform in our present methods of dealing with food frauds and adulterations, and it may be interesting to note how such malpractices are dealt with in France. This country is chosen for two reasons: firstly, because their system is a modern one, designed to meet modern needs; and, secondly, it is one which has given every satisfaction to all parties concerned, for it has been the aim of its makers to give those

subsequent examination will only lead to certifying their genuineness.

These samples, after being sent to the chief of the police at Paris, are given an identification number and then sent straight to one of the laboratories, either owned by the State or worked under its supervision, for analysis.

The Laboratories and their Work.—The chief is that of the State at Paris, whose sole work consists in research work on problems raised during the detection of frauds by the other laboratories under its control, and also the consideration of standard methods of analysis. Next to this there is the Municipal Laboratory, also at Paris, which receives a grant from the Government for all analyses done on samples collected in Paris. For the other towns of France it was not thought necessary to set up any new laboratories, but to make arrangements with those already in existence, so that the Government could have their samples analysed at a fixed rate of 5 francs per sample. Eighteen of these municipal laboratories are already employed under this scheme, and their work consists chiefly in the analyses of foods. For the analysis of agricultural products and fertilisers thirty agricultural stations have been deputed by the Minister of Agriculture, and also two special laboratories for the supervision of wine and fruit culture. In addition to these, such examinations as those of seeds, vine-plants, turpentine, silkworm's eggs, and pharmaceutical products, which present greater difficulty, are examined at certain other places only.

Thus throughout France there is altogether a total of 64 laboratories, either entirely or partly under the control

TABLE I.

	1907.		1908.		1909.		1910.		1911.	
	Number.	% "Suspects."	Number.	% "Suspects."	Number.	% "Suspects."	Number.	% "Suspects."	Number.	% "Suspects."
Milks	5,609	29.6	13,657	20.0	17,750	18.7	18,511	17.4	20,264	18.4
Wines	3,626	16.4	7,300	8.8	8,564	11.7	11,689	12.8	12,292	15.6
Vinegars	428	29.4	814	15.1	733	11.5	663	10.5	651	9.8
Ciders	348	8.6	560	27.3	753	11.2	1,086	14.5	1,232	19.5
Beers	294	20.8	721	3.1	969	1.5	932	2.2	998	0.8
Spirits	472	11.6	1,732	11.6	1,672	14.4	1,598	11.0	1,725	14.0
Butters	1,281	13.6	2,410	11.4	1,768	11.2	2,210	12.7	2,319	13.6
Oils	1,739	42.7	3,744	19.6	3,584	9.6	2,969	8.0	2,799	6.7
Seeds and animal foods .	1,739	42.7	1,991	12.2	2,023	7.8	1,764	9.2	1,743	8.3
Other products	9,262	8.4	24,167	6.1	23,520	5.3	23,993	4.4	23,049	3.5
Total and mean . . .	23,059	18.3	57,096	11.6	61,136	10.9	65,415	10.5	67,066	11.3

accused every opportunity of defending themselves, so as to avoid possibilities of unjust sentences.

The Collection of Samples.—This task was at first undertaken by police officials, but these have now been almost entirely relieved by the appointment of 950 special officials for this purpose. These are chosen from lists of men nominated by the mayors and manufacturers' committees in certain districts. These officials are controlled by fifty inspectors, whose whole time is devoted to the work of seeking possible sources of food adulteration and in keeping the standard of purity up to as high a level as possible. The samples collected are not taken at random, but the officials endeavour to collect samples from sources which their experience points out to them as most likely to lead to cases of adulteration, rather than those whose

of the State, for the suppression of food frauds and adulterations. Of these 14 may be cited as belonging to the Minister of Agriculture; 5 to the Minister of War and Public Instruction; 26 as being attached to other State departments; and 19 to municipalities.

For the analysis of these samples standard methods of analysis are issued for use by the State Laboratory of Paris, and these are not designed so much to expose those samples which are excellent or those which are undoubtedly very bad—for these results follow without any difficulty—as they are for those of such intermediate quality as to be termed "suspects," and whose purity is open to doubt. To be placed in this class, however, does not necessarily mean condemnation, for further investigation, especially as to the samples' mode of origin, may lead to the "suspect" being

later classified as "passable." The principle underlying these analyses is that of bringing to light possible sources of adulteration, but without actual condemnation at this stage.

After the report of the suspected sample has been returned to the Chief of the Police at Paris, the next step is the confirmation or otherwise of adulteration. For this end the law and science combine hands through the medium of chemical experts and arbitrators. The maker or seller of the suspected sample is ordered to appear before a judge, who appoints one of these experts for the prosecution and allows the accused the option of appointing one for his defence. These experts of equal authority are then expected to accumulate all the necessary technical evidence regarding the sample under their consideration, even having research work carried out at the State Laboratory, if they consider it necessary, and to draw up their respective reports. These two experts then discuss their respective reports together, and the result of their discussion is formulated in a common report. If their opinions are in concordance, their report is then handed to a judge, who examines it and passes a

TABLE II.

Judgments.	1907.	1908.	1909.	1910.	1911.
No. of sentences .	1,188	4,035	4,598	3,801	4,193
Penal fines, in francs .	272,082	514,497	453,548	484,990	494,158
Fiscal fines, in francs .	272,082	56,450	284,098	4,224,063	789,303
Imprisonment, in days .	13,324	23,888	14,919	14,890	15,809
Notices published .	13,324	273	583	369	406
Acquittals .	—	57	150	134	97

sentence of guilt or acquittal. If, on the other hand, these two experts cannot come to the same opinion, then a technical arbitrator is appointed by the judge to consider the report of the two experts, to pass an opinion one way or the other, and to communicate his decision to the judge, and this decision is considered absolutely binding.

It is in this way that the law aims at giving those accused every possible opportunity of defending their honour and interests, and, moreover, it is a system which has given very general satisfaction, especially to honest manufacturers and sellers, who have up to the present had to suffer much from the prejudice of the public caused by their less honest members.

The above statistics show the large amount of work which has already been accomplished in this new sphere of activity, and although it proves that the adulteration on the total number of samples collected has decreased from about 18% in 1907 to about 11% in 1911, yet it also proves that further activity is needed in this direction.

Table I. shows the number of samples taken in the years 1907—1911 and the number of these declared as "suspects."

The number of samples collected in 1912 was, approximately, 80,000.

Table II. gives an analysis of the judgments passed on these suspected samples.

NOTES OF MEETINGS.

Chemical Society.

December 4th. "Action of Sulphuric Acid on Copper," by (late) J. T. Cundall. "Reactions which occur when Glycerol and Oxalic Acid are heated together whereby Formic Acid and Allyl Alcohol are produced," by F. D. Chattaway. "The Rotatory Dispersive Power of Organic Compounds. Part V. A Comparison of the Optical and Magnetic Rotatory Dispersions in some Optically-active Liquids," by T. M. Lowry, R. H. Pickard and J. Kenyon. "Organic Derivatives of Silicon. Part XX. Some Condensation Product of Dibenzylsilicanediol," by R. Robison and F. S. Kipping. "Relation between Chemical Constitution and Depth of Colour of Dyes," by E. R. Watson. "Dyes derived from Quercetin," by E. R. Watson and K. B. Sen. "An Improved Form of Apparatus, based on the Landsberger-Sakurai Process, for the Determination of Molecular Weight," by W. E. S. Turner and C. T. Pollard. "The Rotation of Optically Active Derivatives of Siccinic Acid in Aqueous Solutions of Inorganic Salts. Part I.," by G. W. Clough.

December 18th. Papers to be announced.

Society of Chemical Industry.

LONDON SECTION.—December 1st. "Use of Antiseptics for Soil Sterilisation Purposes," by E. J. Russell and Mr. Buddin.

Society of Public Analysts.

December 3rd. "Sulphuretted Hydrogen from Artificial Graphite," by W. H. Woodcock and Bertram Blount. "Determination of Strychnine in the Presence of Quinine," by C. Simmonds. "Rate of Liberation of Hydrocyanic Acid from Linseed," by S. H. Collins and H. Blair. "Composition of Palm-Kernel Oil," by G. D. Elsdon.

Biochemical Society.

December 9th. Ordinary Meeting, Lister Institute, at 5.30 p.m.

Society of Arts.

December 3rd. "Perfumery," by J. C. Umney.
December 11th. "Indian Indigo," by Professor W. P. Bloxam.

Royal Photographic Society.

December 2nd. Technical Meeting.
December 9th. Ordinary Meeting. Presidential Address by Chapman Jones.
December 16th. Technical Meeting.

Institution of Civil Engineers.

December 2nd, 9th, 16th, and 23rd. Ordinary Meetings.

Institution of Mechanical Engineers.

December 4th. "Thomas Hawksley" Lecture. "Water as a Mechanical Agent," by Mr. Edward B. Ellington.

December 19th. General Meeting.

Institution of Electrical Engineers.

December 4th. Address on "Electricity Supply in Large Cities," by Dr. G. Klingenberg.

December 18th. "The Employment of Power in H.M. Post Office," by H. C. Gunton.

UNIVERSITIES AND COLLEGES.

THE DEPARTMENT OF METALLURGY IN THE UNIVERSITY OF BIRMINGHAM.

By PROFESSOR THOMAS TURNER, M.Sc., A.R.S.M.

THE population of Birmingham and the neighbouring towns of south Staffordshire and north Worcestershire is well over two millions, and the majority of these persons are directly or indirectly dependent upon the metal trades for their comforts, or even for their very existence. It is fitting under the circumstances that the subject of metallurgy should occupy a prominent position in general schemes of higher scientific and technical education in the locality. The University of Birmingham is the lineal descendant of the old Mason College, which was built and endowed by Sir Josiah Mason less than forty years ago. Sir Josiah had himself

is now one of the largest, best equipped, and progressive in the British Empire, while its past students and graduates are to be found in all the continents, doing useful work, and, in many cases, occupying very important positions. Instruction in metallurgy was originally given in the Mason College buildings, but since 1904 the whole of the work of the metallurgical department has been conducted in the new laboratories in the university buildings at Edgbaston. These are about three miles from the centre of the city, and are very pleasantly situated on a site which is nearly 50 acres in area. An electric tramway provides ready



FIG. 1.—PLAN OF METALLURGICAL LABORATORIES, ETC.

been connected with the steel pen trade, with the introduction of electroplating, and with the nickel industry; it was, therefore, natural that the charter of the college should provide specifically for the teaching of metallurgy. On account of other needs it was not possible to provide a metallurgical department in the early years of the college, but a lectureship in metallurgy was established in 1886, and to this lectureship the present writer was appointed. Soon after the foundation of the university in 1900 arrangements were made for a properly organised and equipped department and professorial chair, and this chair has more recently been endowed by a legacy of £20,000 under the Feeney bequest. It may reasonably be claimed that the department

communication between the new buildings and the Mason College.

A visitor to the Metallurgical Department will find that it includes two separate portions, one of which is situate in the main building, while the other is a self-contained block near the university power house, some 400 yds. distant from the main laboratory. In the main building are the lecture-rooms, laboratories, and museums, while the separate block contains the smelting laboratories. About 20,000 sq. ft. of floor space is devoted to metallurgy in the main building. The department is placed on the main ground floor, on which there is a spacious and well-lighted suite of sixteen rooms, including elementary and advanced laboratories which provide

for sixty students to work at one time. There is a separate dry assay laboratory, a lecture theatre, and two store-rooms complete this part of the department, and together account for 13,000 sq. ft., while upwards of 6,000 sq. ft. on the first floor is devoted to the metallurgical museum (see Fig. 1). The samples in this museum number several thousands; they are systematically arranged in the order of the chief course of lectures, and they are available for reference or research at any time.



FIG. 2.—BESSEMER CONVERTER FOR COPPER MATTE.

balance-room, and advanced class-room and reading-room. Additional rooms are devoted to pyrometry,

In the separate block devoted to large scale operations there is a 2-ton Siemens steel-melting furnace (Fig. 3) with an electric hoist, hand crane, ladle, and ingot mould and pit. Courses of instruction in this work are held twice yearly, and senior and graduate students are required to attend. Upwards of 200 men have already taken part in the steel courses. There is a section of similar area devoted to the "non-ferrous" metals, and this includes a water-jacketed blast furnace (Fig. 4) and a cyanide plant for the treatment of gold ores (Fig. 5). Other apparatus in this section is a hand-fired reverberatory furnace, a rotating calciner, and a cupellation furnace. In the summer vacation course copper matte is bessemerised in a small converter designed and made in the depart-

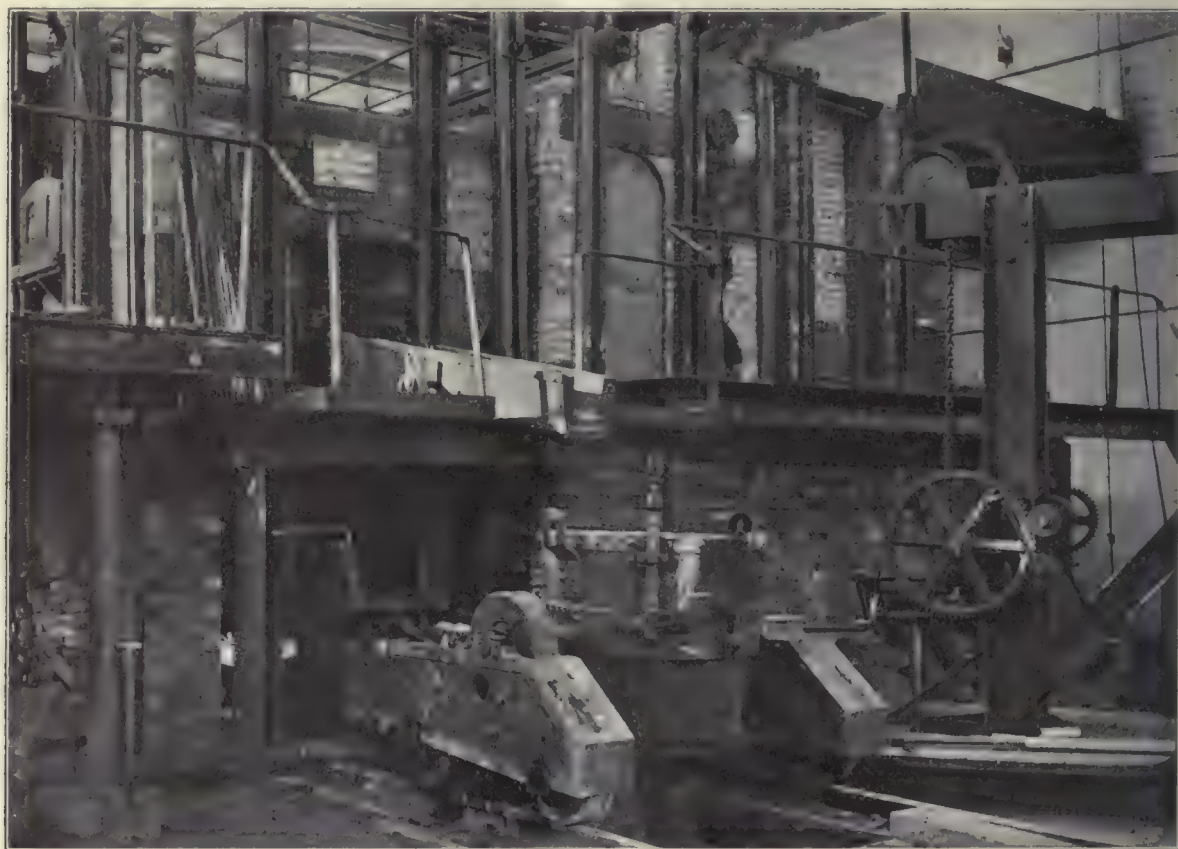


FIG. 3.—SIEMEN'S STEEL MELTING FURNACE.

to metallography, and to electro-metallurgy, while there are also rooms for ore sampling and for metal working. The professor's office, the lecturer's room,

ment (Fig. 2). In two other rooms in this section there are respectively a small foundry for brass and steel, and an electric furnace installation. Experi-

ence in the working of this practical plant has shown not merely that it has considerable educational value, but that it can be worked economically, and that it is much appreciated by the students.

The Chancellor of the University (the Right



FIG. 4.—WATER-JACKETED BLAST FURNACE.

Hon. Joseph Chamberlain, M.P.) in some of his earlier addresses in connection with the establishment of the university expressed a hope that the work to be conducted would have a threefold object; that it would, by its teaching be of advantage alike to the locality and to the Empire, while, at the same time, research would occupy an important part of its activities. These aims have been borne in mind in developing the metallurgical work. The primary object is to give men a training in metallurgical principles such as will fit them for positions of responsibility in this country, and most of the graduates find employment in the United Kingdom, chiefly in the Midlands. A considerable proportion, however, go abroad, chiefly to South Africa, India, and other parts of the British Empire.

Research has always been conducted in the department, and the subjects investigated have been so numerous and so varied in character that only a brief summary can be attempted. The first important research had reference to the relationship between the composition and the properties of cast iron, and especially the influence of silicon in cast iron. In the words of Dr. Moldenke the results obtained "laid the foundation of modern scientific ironfounding." The theory of the puddling process was next investigated and considerable new

light thrown upon this important subject. Investigations in the tempering of steel, the hardness of metals, the production of malleable cast iron, and the influence of silicon in steel followed in due course. With the increased facilities and better equipment of the new department other investigations have been conducted, such as those on the micro-structure of cast iron, in which were first demonstrated the connection between strength and graphite size. The annealing of brass and of German silver supplied ground for investigations in a new field in another direction. During the last few years a series of papers have appeared on the volume changes which occur during the solidification and subsequent cooling of cast metals, and also on the behaviour of metals when heated in a vacuum. One may also recall published papers on the corrosion of brass, on the case-hardening of steel, the constitution of slags, oxygen in brass, and of manganese of sulphur, and of silicon in cast iron. Several papers of antiquarian interest have appeared from time to time, together with a description of the manufacture of wrought iron in blast furnaces in India. Altogether, considerably over 100 published papers have been issued by the department, and one characteristic of the work has been that the men have been encouraged to make their own apparatus, so far as this has been possible. Hence many of the researches have been



FIG. 5.—CYANIDE PLANT FOR GOLD ORES.

conducted with relatively simple forms of apparatus designed and made in the department itself.

It is evident that for the conduct of work of such variety and magnitude numerous willing helpers

have been required. First among these should be named Mr. O. F. Hudson, M.Sc., who, for the past eleven years, has been lecturer in metallurgy, and primarily responsible for the practical instruction. The skill of Mr. Ward, the university steel melter has often been invaluable. The following list gives, in order of date, the names of those who can be recalled at the moment whose work has been published in one or more of the journals of the leading scientific and technical societies. Messrs. Jordan, Barrows, Harris, Royston, Picken, Simpson, Schnurmann, Bengough, Andrew, Shaw-Scott, Levy,

Murray, Hague, Brühl, Johnson, Grayson, Coe, Ewen, Haughton, Nevil, Cartland, Gwyer, Brown, Austin, Groves, Nair, and Chamberlain. A good deal of research has also been conducted the results of which did not call for publication. To all who have assisted in the work, whether mentioned by name or otherwise, I would venture to extend my thanks and good wishes. I would further express a hope that the newer generation of students may worthily carry on and extend the traditions of the department to which they belong.

MOLECULAR PHYSICS.

By J. A. CROWTHER, M.A. (Fellow of St. John's College, and Demonstrator in Physics in the Cavendish Laboratory, Cambridge).

CHAPTER VII. (*continued*).

THE ATOM IN VIBRATION.

THIS was first pointed out by Balmer for the hydrogen spectrum, but it was afterwards shown by Rydberg that Balmer's equation was merely a particular case of a very general law which could be stated so as to apply to all the elements giving series spectra. He showed that if n is the frequency of the vibrations corresponding to a given line (the frequency is the number of vibrations made per second by the particle emitting the light) then the frequency of all the lines in a given series can be represented by the equation—

$$n = n_0 - \frac{N}{(m + \mu)^2}$$

the different lines composing the series being obtained by putting m equal successively to the whole numbers, 1, 2, 3, . . . N is a constant so universal in its character that it applies not merely for all the series of a given element but for all the series of all elements giving series spectra at all. The constants n_0 and μ differ for different elements and are characteristic of the particular series.

That this method of classifying a spectrum is no mere mathematical fiction is very clearly brought out when the character of the lines making up a single series is closely observed. It is found that all the lines of a single series are exactly similar in appearance. Thus all of them appear sharp and distinct with definite clear-cut boundaries, or else they are all indistinct and diffuse. The two types of lines are never associated in the same group. Again, any physical change which we bring about in one of the lines of a series is reproduced simultaneously in all the others. Thus, all the lines split up in the same way under the action of a magnetic field. If one of the lines is broadened by the application of pressure to the gas emitting the spectrum, all the others are broadened to a similar degree, and when the method of producing the

spectrum is altered, all the lines have their brightness either enhanced or diminished at the same time. We can hardly avoid the conclusion that they are all different modes of vibration of the same system.

An analogy may make this clearer. It is well known that when an organ pipe is sounded it gives out in addition to its fundamental note a series of overtones, the fullness and richness of the organ notes being due to the presence of these extra tones. In such a simple system the overtones are always harmonics, that is to say, their frequencies are always exact multiples of the lowest mode of vibration. In mathematical language we can say that the different frequencies are obtainable by substituting various whole numbers for the quantity m in the equation, $n = m \cdot n_0$.

In more complicated vibrators the relationship becomes more complicated while at the same time the importance of the overtones becomes even more pronounced. In the case of a sounding bell the relation between the different modes of vibration is so complicated that it has not yet been completely worked out.

This is not all, however. Not only do the spectra of a single element show these close numerical relationships. They are also found to exist between the spectra of different elements belonging to the same group of the periodic table. The spectra of the different elements of the alkali metals, for example, are so closely connected that it is actually possible to calculate the whole spectrum of, say, rubidium or caesium, from that of potassium, and a knowledge of the relative atomic weights of the three elements. The spectrum of caesium is practically the same as that of potassium but is shifted bodily towards the violet end of the spectrum. We are thus driven to the conclusion that the vibrating systems in the two cases are identical in form, and differ from each other only in being placed in slightly different environments.

In terms of our model atom, if we regard the series spectra as being given out by the inner rings of electrons, these rings are identical for the three

elements, but in the case of the two latter the extra outer rings added on to increase the atomic weight produce some alteration in the external forces acting on the rings and so cause a shift in the absolute frequencies of the vibrations without altering the relation between them. In the words of astronomical theory, the outer electrons perturb the vibrations of the inner ring without destroying their character. Or, returning to our analogy of the bell, it is the same bell which is sounding but in a somewhat different medium.

One difficulty, a very formidable one, remains, and may, perhaps, already have occurred to the reader. The spectra of many of the elements is exceedingly complicated, containing in some cases many hundreds of well-defined lines. A contemplation of the iron spectrum, wrung from the great American spectroscopist Rowland the exclamation that, compared with an atom of iron, a grand piano must be a very simple affair indeed.

We have seen, however, in a former chapter that the number of electrons in an atom is, on the whole, not very large. In all probability the hydrogen atom contains only one electron, and certainly not more than three. A single electron has only three degrees of freedom and therefore only three modes of vibration, and in the simple atom these three would all have the same period and thus coalesce into a single line. As a matter of fact, the ordinary spectrum of hydrogen contains a fair number of lines while what is known as its secondary spectrum is very complicated. The difficulty seems at first sight almost insuperable.

To solve the riddle, Professor Sir J. J. Thomson has hazarded the bold but almost certainly correct conjecture that the lines in the spectrum of hydrogen and, indeed, of many other elements are not emitted by the atoms of the element at all but by systems which only exist when the gas is thrown into a luminous condition. When we consider the absolute identity of the spectrum of an element whether situated on the earth or away on the furthest star, of which we have spectroscopic data, this hypothesis may seem to be the most startling we have yet advanced. It is, however, not without a very considerable experimental basis.

Consider for a moment the phenomena known as selective absorption of light, of which the well-known experiment of the reversal of the sodium lines is a good example. If white light is passed through sodium vapour enclosed in an iron tube and the transmitted light examined with a spectroscope there can be seen across the ordinary coloured spectrum two sharp, dark lines, corresponding exactly in position with the two bright lines, which would be seen if the sodium were raised to incandescence. This is the cause of the dark Fraunhofer lines which are to be seen crossing the spectrum of the light from the sun.

These effects are due to a form of resonance. The sodium atom contains systems of electrons which, when suitably excited, give out light of the frequency corresponding to the two sodium lines. To use an analogy from sound or from wireless

telegraphy the sodium atom is tuned to this frequency. It will therefore begin to vibrate violently if oscillations of this period fall upon it. In doing so it abstracts the energy of the radiation in tune with itself, so that the latter is very rapidly absorbed, while light of frequency remote from this passes on almost unaffected. Thus, after passing through a very small thickness of material the light is robbed of all the constituents which have a frequency corresponding to those of the radiating systems within it. Conversely all the electronic systems which have natural periods falling within the limits of the visible spectrum must produce a dark band when white light is passed through them.

Now, it is remarkable that such absorption lines are not seen when white light is passed through a column of hydrogen, or indeed of most other simple gases. There are, for example, no dark lines to be seen in the spectrum when examined after passing through a long tube of hydrogen gas, corresponding to, say, the brilliant lines of the hydrogen spectrum in the red or in the blue. Indeed, the laws of the absorption and dispersion of light in hydrogen are so simple that they can be explained on the assumption of a single absorption band far away beyond the violet end of the spectrum. This is, of course, what we should expect from the simple nature of the hydrogen atom. There is thus no escape from the conclusion that the vibrating systems which emit the hydrogen spectrum are not present in the gas in its normal condition.

A very interesting experiment made not long ago by Ladenburg has shown, however, that they can be manufactured in the gas under suitable conditions. He passed the light from a very bright discharge in hydrogen at fairly high pressure through a long tube of hydrogen at much lower pressure, fitted with terminals for the passage of a discharge, and examined the light transmitted with a spectroscope. His apparatus is indicated very diagrammatically in Fig. 28. The effect of the high pressure on the discharge is to widen out all the lines in the spectrum so that, instead of a narrow line a broad band of light is seen overlapping the original line on each side. When there was no discharge passing through the long tube of hydrogen there was no trace of any absorption of any part of this broadened band. If, however, a feeble discharge was sent through this long tube of gas it was seen that the centre portion of the broad line corresponding to the original line and hence having the period of the light emitted by the tube at low pressure became distinctly less bright than the outer portions, showing that the long column of feebly glowing gas was now absorbing from the light emitted by the brighter hydrogen tube those wave lengths corresponding in period to the light it was itself giving out. There are some difficulties in the experiment, and a certain synchronism of the two discharges seems to be necessary for its success. On the whole, the conclusion seems irresistible. The hydrogen line spectrum is emitted by systems of electrons which are not present in the gas in its normal condition, but which are formed when the gas is thrown into a luminous state.

Let us consider for a moment the ways in which an atom can be made to emit luminous vibrations. Experiments have shown that for an atom to emit its characteristic spectrum it is necessary that it should be in a region of intense ionisation or recombination. It seems that nothing short of driving an electron into or out of the atom will suffice to set in vibration the light emitting systems of electrons. It is obvious that this condition is fulfilled when the spectrum is excited electrically, either by sparking between terminals of the substance or by a low pressure discharge through a gas. It is interesting in this connection to note in the latter case that experiments have shown that, in the dark portions of the discharge the ionisation is very feeble, while it is most intense in the brightest portions of the positive column. The ordinary method of producing a spectrum by placing the substance in a Bunsen flame is also merely a rough-and-ready way of producing ionisation in the

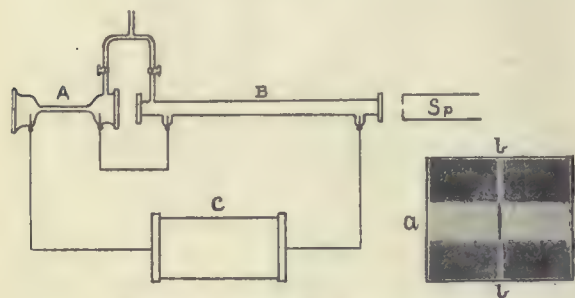


FIG. 28.—LADENBURG'S EXPERIMENT.

A, discharge tube containing hydrogen at high pressure. B, discharge tube containing hydrogen at low pressure. C, induction coil working both tubes. Sp, spectrometer for viewing the light transmitted. The inset shows the appearance seen in spectrometer when the tubes are working. aa, broadened band due to hydrogen in A. bb, spectrum due to the tube B alone. The dark line where the two bands cross shows the reversal of the line by the systems formed in B by the discharge.

substance, Professor H. A. Wilson having shown that a Bunsen flame, especially if it contains salt vapours, is the seat of very intense ionisation.

Consider an atom placed within this ionised space. It meets the ionising agent and an electron is ejected, leaving the atom with a positive charge. The loss of this electron will alter the forces within the atom and the remaining electrons will oscillate about their new positions of equilibrium before finally settling down. These vibrations, if of suitable periods, will set up luminous radiations and give rise to a set of lines in the spectrum. The positively charged atom is now surrounded by a cloud of negative electrons which fill the surrounding space. It attracts them and, normally, one would enter to take the place of the lost member. If however, the mutual kinetic energy of the two is sufficient the electron will revolve round the attracting atom without falling into it in exactly the same way as the earth revolves around the sun. The revolutions of this electron, being isochronous, will give rise to a single line in the spectrum with a

period corresponding to the time taken by the electron to describe the circle.

If the law of force between the atom and the electron were a simple one of the inverse squares, an orbit of any size would be possible under suitable conditions. Taking into account the fact that the electron is losing speed owing to the fact that it is all the time radiating away its energy in the form of light waves, it will be gradually drawn nearer and nearer the atom so that its path would be a sort of spiral ending up in collapse into the atom. Since slightly different times would be occupied in describing each part of the curve the spectrum thus produced would be continuous.

The neighbourhood of the electrons within the atom and their repulsion of the external one would complicate the simple law of force, and in general the attraction of the atom for its satellite would depend not only on the distance but also on the direction of the line joining the satellite to the atom. The law of force would thus depend upon the number and arrangement of the electrons within the atom, just as much as if the electron were revolving inside it.

Sir George Darwin, in his monumental work on Periodic Orbits has shown that, if the single system of a satellite revolving round its planet is disturbed by the presence of a third body, the number of orbits which the satellite may describe is no longer infinite, but that there are certain regions through which the particle must not pass if it is to continue to revolve as a satellite around the planet. In the simple case considered by Darwin this space did not quite enclose the planet, but in the more complicated cases we have to deal with when we come to a consideration of the atom, he was of the opinion that it might very well take the form of a series of closed rings surrounding the atom. In this case there would be a series of separate rings in which alone the electron could revolve, and each of which it would describe in a definite time peculiar to that ring. Each of these rings would thus give rise to a separate line in the spectrum. Since the atom would only attract one electron at a time each atom would at one time be only emitting one of these extra lines.

These systems would, of course, not be permanent, as the electron would constantly be losing energy by radiation. After a time its energy would fall below that necessary to keep it in rotation in the ring it was describing, and it would collapse through ring after ring, until finally it was reabsorbed into the atom. Fresh systems would, however, be constantly being formed in the ionised gas, and the supply would be kept up as long as the exciting conditions were maintained.

The return of the lost electron into the atomic fold would obviously stir up fresh vibrations among the electrons already present. Since the atom is now neutral and not positively charged as it was when the electron left it these vibrations would not have the same periods as those set up when the electron was expelled. There is some evidence for the suggestion that the vibrations corresponding to

the return of the electron from the band spectrum of the element, while those set up on its expulsion, together with those due to the special systems, make up the different series of line spectra.

Very recently an ingenious Danish mathematician, Dr. Böhr, has worked out mathematically a theory of spectra very much on the lines described above, and has in this way obtained a formula for the spectral series identical in form with the empirical formula of Rydberg which we have already discussed. He has from his theory deduced an expression for the universal constant N of Rydberg's equation in terms of the mass and charge on an electron and other known physical quantities, which gives a numerical value for that quantity within about 5% of the value obtained from direct spectroscopic observations. His assumptions will require further consideration before they can be unreservedly adopted. They appear to involve the abandonment not merely of Newtonian mechanics, but also of the ordinary Faraday-Maxwell electromagnetic theory. The closeness of the agreement between the results of the theory and of experiment is, however, at least remarkable, and seems to show that, at any rate in its general outlines, the theory of the origin of spectra which we have propounded above is a step in the right direction.

We have, however, wandered far from the solid certainties of the Zeeman effect and its consequences, with which we commenced this chapter, into the dark and mysterious hinterland where science is in the making. In a few more years we may hope that this will be transformed into plain and open ground. At present we must pause here, lest we lose ourselves altogether in a quagmire of fascinating but groundless speculations.

Nitrate Production of Chile.—The United States Consul at Valparaiso reports that, during the nitrate year that closed on June 30th, 1913, the production amounted to 59,450,454 Chilean quintals (Chilean quintal equals 101.41 lb.), against 54,572,965 quintals for 1912, with consumption for the same period at 54,908,912 quintals, against 52,985,430 quintals for 1912. The exports for the first six months of 1913 amounted to 26,890,700 quintals, against 22,628,522 quintals for the same time in 1912. The price of nitrate declined from \$2 per quintal on July 1st, 1912, to \$1.84 on July 1st, 1913.—*Chamber of Commerce Journal*.

New Whale Oil Refining Process in Norway.—H.M. Consul at Christiania reports that, according to the local press, a factory near Sandefjord is about to be purchased and adapted by a new company for the chemical treatment of whale oil by a new process invented by an Austrian. The name and address of a gentleman connected with the scheme may be obtained by United Kingdom firms interested on application to the Commercial Intelligence Branch of the Board of Trade.—*Board of Trade Journal*.

Manganese Ore in India.—The value of the ore produced in 1912 increased by 36% over that of 1911. This increase was due rather to increase in price, than production; but the effect of higher prices is expected to lead to an increased output.

PERSONAL AND OTHER NOTES.

Professor A. Werner has been awarded this year's Nobel Prize for chemistry. The prize is worth about £7,800.

The Royal Society has awarded Professor Harold Bailly Dixon one of the Royal medals for his work in connection with physical chemistry, and Professor R. Meldola the Davy medal for his work in synthetic chemistry.

Dr. F. H. Hatch has been elected president of the Institution of Mining and Metallurgy.

Mr. Alexander McKenzie, of the chemical department of the Birkbeck College, London, has been appointed Professor of Chemistry in University College, Dundee, in succession to the late Professor Hugh Marshall.

At the meeting of the Royal Society of Edinburgh, held on November 3rd, Professor Emil C. Jungfleisch, Mem. Inst. Fr., Professor of Organic Chemistry in the College of France, Paris, was elected as honorary fellow.

Mr. F. Powis has been appointed demonstrator in chemistry in the Leeds University.

The Annual Exhibition of the Physical Society of London will be held on December 16th, at the Imperial College of Science, and will be open both in the afternoon and evening.

The Governors of the Imperial College of Science and Technology, South Kensington, have resolved to establish a Chair of Organic Chemistry, as from January 1st, 1912, and are prepared to receive applications for the Professorship.

The Council of University College, Nottingham, offer a Scholarship for Scientific Research, tenable for one year, of the value of £50, together with free admission, open to any graduate of a British University. Candidates will be required to give evidence of suitable training and capacity for conducting original research. The successful candidate will be required to devote himself to some subject of research to be approved by the Senate.

On November 6th Sir Walter Royse (the ex-Lord Mayor of Manchester) of the firm of S. W. Royse & Co., chemical brokers, was presented with a silver cup from the members of his staff on completion of his official duties.

£10,000 has been bequeathed by the late Mr. William Gibson, of London and Belfast, to Queen's University, Belfast.

The following have been recommended by the president and council of the Royal Society for election into the council at the anniversary meeting on December 1st:—*President*: Sir William Crookes, O.M. *Treasurer*: Sir Alfred Kempe. *Secretaries*: Sir John Bradford, K.C.M.G., and Professor A. Schuster. *Foreign Secretary*: Dr. D. H. Scott. *Members of the Council*: The Right Hon. A. J. Balfour, Professor W. M. Bayliss, Dr. F. W. Dyson, Dr. H. J. H. Fenton, Professor W. Gowland, Dr. F. G. Hopkins, Sir Joseph Larmor, Professor C. H. Lees, Professor E. W. Macbride, Professor G. Elliot Smith, Professor J. Lorrain Smith, Sir John Thornycroft, Professor W. W. Watts, Mr. A. N. Whitehead, Mr. C. T. R. Wilson and Dr. A. Smith Woodward.

The Cambridge University authorities have appointed a degree committee of the Board of Agricultural Studies. The extension of the School of Agriculture is practically complete.

CHEMICAL ENGINEERING.

RECENT PROGRESS IN SAMPLING AND TESTING FUELS.

By JOHN B. C. KERSHAW, F.I.C.

Introduction.—That the application of scientific methods for determining the sale and purchase value of fuel is advancing in favour is proved by the growing literature of the subject, and by the increasing tendency of engineers to demand guarantees from the colliery company or from the coal dealers and middleman, that the fuel shall yield on test *a stated number of calories*, or shall contain *less than* a definite maximum percentage of moisture, sulphur and ash.

The additional financial burdens placed upon the colliery owners of this country by the advanced labour legislation of recent years have, in fact, necessitated the use of scientific methods for checking the quality and price of fuel, for not only has the price of fuel been increased by 20% to 30% since these Acts came into force, but the quality has at the same time deteriorated, and every large fuel-user knows only too well that *he is now paying much more, for a worse fuel, than ten years ago.*

The Eight-hours'-day Act has been the chief factor in causing a deterioration in the quality of the fuel raised and sold, a deterioration which is most marked in the case of the cheaper qualities of slack and small coal, sold in large quantities for steam-raising purposes. In order that the miner may produce his daily quota of output, he has to work with less care than formerly, and a much larger proportion of shale and dirt is now brought to the surface with the coal than was the case ten years ago. In support of this assertion the following extract and figures may be quoted from the *Iron and Coal Trades Review*.

"In order to minimise that Act's restrictive effect on outputs, every effort has been made by colliery managers to accelerate the rate of production, and, apparently, one of the many consequences of these efforts has been increased carelessness in the filling of trams, and a corresponding decline in the quality of small coal. A few instances may be mentioned in illustration. In February last, the percentage of ash yielded by colliery A. was 11.20; last month the percentage was 14.18; in the case of D. it has increased from 10.83 to 13.28; whilst in other cases it has increased from 8.90 to 13.96; from 11.0 to 13.52; from 11.32 to 12.40; from 11.10 to 13.96; and from 16.36 to 18.88."

The above figures refer to the South Wales steam coals, and corresponding figures for Lancashire

collieries would show probably a much worse deterioration than the above.

The proportion of smalls in every 100 tons of coal raised has also increased enormously since the Mines Eight-hours Act came into force. The writer of this article has tested quite recently a large delivery of slack, sold by a well-known Lancashire colliery company for steam-raising purposes, which gave the following results when graded in the laboratory:—

Slack left on $\frac{1}{4}$ -in. mesh sieve	48%
Fine slack passed through $\frac{1}{4}$ -in. mesh sieve	52%

The latter portion of the slack was again graded into two proportions by use of a $\frac{1}{2}$ -in. mesh sieve, and it was found that nearly one-half of this portion, or 24.3% of the original weight of slack, was composed of fine dust that passed easily through a $\frac{1}{2}$ -in. mesh sieve. Separate ash tests of these three grades of slack were then made, and the test results are sufficiently interesting to be given here—

Slack left on $\frac{1}{4}$ -in. mesh sieve	11.15% ash.
Fine slack between $\frac{1}{4}$ -in. and $\frac{1}{2}$ -in. mesh	19.20% „
Dust, under $\frac{1}{2}$ -in. mesh	29.60% „

Nearly 25 tons of every 100 tons of this slack as delivered was therefore practically valueless as a fuel in any ordinary boiler furnace, and in this particular case it only served to clog up the air passages of the fire-bars, and to prevent proper combustion of the remaining 75% of the fuel. To charge 13s. 6d. per ton for such a slack was a gross imposition upon the fuel user. Instances of a similar kind could be given in large numbers,¹ but enough has been said to prove that during the past ten years the quality of fuel has deteriorated enormously, while the price has increased, and that the need for the application of scientific methods of controlling the quality and price of fuel was never more urgent than at the present time.

In this and the following article details will be given of the methods in use in Germany, Switzerland, the United Kingdom, and America for sampling and testing fuel in transit or when discharging at the consumer's works. Some examples of forms of contract, in which the price paid for the fuel is made dependent either upon the calorific value, or upon the percentage of ash, will also be given.

Germany.—The information relating to German

¹ The Aisgill railway disaster was really due to this same cause—bad fuel.

methods has been obtained from Dr. Aufhauser, head of the Thermochemische Prüfungs-und Versuchs-Anstalt in Hamburg. The fuel testing for the members of the Hamburg Verein für Feuerungs-betrieb und Rauchbekämpfung is carried out at this laboratory, and the recent reports of this society contain the results of many hundreds of tests of samples of English and German coals, which have been made in Dr. Aufhauser's laboratory. A large number of members of the Verein-für Feuerungs-betrieb are now having their supplies of fuel sampled and tested regularly, the usual plan being to take separate samples of each 50 tons of coal as delivered, and to have these samples tested for moisture and ash, and also for calorific value in a Berthelot and Mahler bomb-form of calorimeter. In some cases the users of the fuel have been able to arrange contracts with the middleman or colliery agents, in which the price paid varies with the monthly average of these calorimeter tests, the basis of the contract being a fixed price per 100,000 calories; that is *heat energy and not coal is bought and sold*. In the majority of instances at Hamburg, however, only two limits are inserted in the contract, namely a minimum calorific value and a maximum percentage of ash. The seller of the fuel then contracts to deliver a fuel which shall not fall below a certain stated calorific value or contain above a certain stated percentage of ash, and if any delivery of fuel is found which does not fulfil these conditions of sale it is either returned to the seller or an allowance is made on the price. *Average tests* of the monthly deliveries are taken in deciding upon the value of the fuel, and slight variations up to 1% or 2% are generally overlooked. Very bad or dirty samples are speedily detected by the wide deviation of the test results from the average of the deliveries, and the tests of such samples are not included in the average, unless the sampler is convinced they represent fairly the deliveries on the particular occasion when they were taken. Although the colliery companies and middlemen prefer this form of contract to the former one, it is really the more rigorous of the two, for it contains no possibility of the price being increased, when the fuel actually supplied is rather better than that contracted for. The simpler form of contract is, however preferred, and not only in Hamburg, but also in many other industrial centres of Germany, the supplies of fuel are now being purchased under what is practically a chemical guarantee of quality. Over 1,000 samples of fuel were tested at Hamburg in 1909, and the work of Dr. Aufhauser's laboratory has increased greatly in the four years that have elapsed since that return was published.

Switzerland.—The facts and figures relating to the progress of fuel sampling and testing in Switzerland have been obtained from Professor E. J. Constam, Director of the Federal Fuel-testing Laboratory at Zurich. The erection and equipment of this laboratory was one result of the purchase of the Swiss railways by the State in 1902, and of the fact that all the fuel required for working these railways was purchased in Belgium, England,

France, or Germany, generally in the form of briquettes. The laboratory is an annexe of the Zurich Polytechnic, and is really an extension of the old thermo-chemical laboratory, the extensions and equipment having cost about £2,000 and having been completed in 1907. In the year 1908 (the first of its existence) over 3,300 samples of briquettes and coal were tested in this laboratory, and the latest available figures show that this total had been increased to 5,400 in 1910. The laboratory examines fuel for private firms and individuals as well as for the State railways, and from time to time the results of its investigations are published in the form of a report.

As the value of briquettes depends largely upon their ability to stand handling without falling to pieces, an important test at this Federal laboratory is that for "cohesion." This test is carried out as follows:—

Fifty kilogrammes of briquettes are put into a drum of the cohesion machine in $\frac{1}{2}$ -kilo. lumps. The machine is set in motion, and, after making fifty turns in two minutes, the contents are emptied on to the gridiron and shaken; what remains behind is weighed. This is expressed as a percentage and gives the value of cohesion, which, in the case of good briquettes, should not be less than 55%.

The very large number of tests carried out at this State-aided laboratory has had good results in Switzerland, for it has tended to enlighten the consumers as to the relative economic values of the fuels they have been importing from the various countries, and has assisted in the classification of these according to their heating power.

The Director of the Federal Fuel-testing Laboratory is a firm believer in the use of the thermal value of a fuel as basis of the fuel contract, and is doing all he can to get this system of purchase adopted in Switzerland.

Both the coal producers and the consumers are stated to be satisfied with the methods of fuel sampling and testing adopted at the Zurich laboratory. The results of the tests are compiled monthly and are communicated to both the sellers and buyers of the fuel. In the case of *briquetted fuel* the settlement is effected by adding or deducting from the price a proportionate sum for every 90 B.T.U. by which the average monthly calorific value of the fuel actually delivered differs from the standard calorific value inserted in the contract.

The United Kingdom.—Although a very large amount of fuel testing is being carried on in this country at the present time, in the laboratories of technical colleges and universities, of independent experts, and of works and factories, it is not easy to find any record of what is being done, since the English manufacturer and works manager is extremely unready to make his methods of control and management known to the world at large, even when these contain little that is novel or of patentable value. It is known, however, that in a large number of works and factories where fuel is an important item in the cost of production the deliveries of fuel are regularly and systematically

sampled, and that these samples are either tested in the laboratory attached to the works, or are sent to some independent institution or analyst for examination. The practice of making use of the laboratories of public teaching institutions for this work is unfortunately growing, and in many places the permanent staff of the engineering departments of technical schools and university colleges are engaged in making calorimeter tests of fuel (either free of charge or at reduced rates) for the various authorities and persons who consider they have a claim upon their services. Since these technical schools and universities receive large grants in aid, both from the local rates and from the general revenue, this form of competition with the independent analyst and fuel chemist is most unfair, and ought to be stopped.

With regard to the form of the fuel contracts used in the United Kingdom, little progress has been made yet in persuading the colliery companies or the coal dealers to sell coal on a sliding scale basis—*i.e.*, to sell calories or heat units in place of tons of coal; and the majority of fuel contracts are based on the system of guaranteeing a certain definite standard of quality, expressed in British thermal units and percentages of moisture and ash. Should the coal actually supplied not come up to this standard of quality the delivery may be rejected. This form of contract suffers from the grave defect that in nine cases out of ten, *the fuel is discharged and is partly or wholly used* before the deficiency in British thermal units or high percentages of moisture and ash are discovered. The rejection of the fuel is, therefore, a course which can rarely be adopted, and as the colliery company is protected in this natural manner from the operation of the clause, the adjustment of price which ought to follow the delivery of bad fuel seldom occurs. The systematic sampling and testing of the fuel which is going on, however, has some effect in keeping up the quality of the fuel delivered. A contract with a clause defining the quality of the fuel purchased in British thermal units, and setting limits to the allowable percentages of moisture and ash, is certainly an advance upon the form of contract in use fifteen or even ten years ago, when only the mine and seam of coal were named in the clause specifying the quality. The fact that the coal producers and middlemen have been educated up to the point of understanding what a British thermal unit is, and of allowing figures representing the calorific value of the fuel to be inserted into the contract, proves that some progress is being made although this may be slow; and the writer of this article is still hopeful that in a few years, fuel contracts, based on a sliding-scale arrangement, in which the price will vary with the quality of the fuel delivered, will be quite common in this country.

Some practical examples of the methods of control that have been tried, or are now in force, in the United Kingdom, will now be given. These are drawn chiefly from the records of the electrical supply companies. Since the engineers of these undertakings are up-to-date in their methods and

quite ready to answer inquiries—the writer is most in touch with what is being done in this branch of the engineering industry.

(A) *A large municipal electrical supply undertaking in Scotland.*—The chief engineer reports that samples are taken daily of all the coal, a small scoopful of coal being taken by the checkweighman from each ton load delivered. These small samples are stored in a clean receptacle, until the barge or waggon is empty. The sample is then reduced by crushing and quartering to one of 3 lbs. and this is forwarded in a sealed tin to the testing laboratory of the electricity department. The contents of the tin are there crushed and still further reduced in bulk in the usual manner, and the calorific value of the sample is finally determined in the bomb type of calorimeter. If the tests show that the fuel being delivered is below the standard set for the particular pit from which it is shipped, complaint is immediately made, and the cause of the deterioration in quality is usually found to be *careless mining and picking of the coal*. By this means the engineer of this works reports that they have obtained a thorough working knowledge of the relative values of all the fuels mined within a practical distance of the electricity generating station, and when offers of coal are made, they can bring all prices down to a common calorific basis by use of their past test-records for each pit. Although the contract is not based on heat units, they are thus able to bring the contract price into close agreement with the real calorific value of the fuel.

(B) *A large municipal electrical supply undertaking in the Midlands.*—The chief engineer and general manager reports that the fuel is sampled and tested daily. Samples are taken from the rotary filler, supplying a conveyer, at intervals during the unloading of each boat, the coal in this case being delivered by canal. Each day's samples are mixed, and are quartered down into two lots of convenient size. One of these is tested for calorific value, ash and moisture daily, the other portion is put with the previous day's sample in order to make up the weekly average sample of fuel.

The contract stipulates for a certain calorific value and ash percentage, but the price is not dependent upon the quality. This latter must, however, be maintained, or the fuel can be rejected; and if not rejected, a claim can be made for a reduction in price, based on the average figures of tests taken over the period in question.

(C) *A large municipal electricity supply undertaking in the north of England.*—The chief engineer reports that all the fuel delivered is sampled and tested at regular intervals, and that the form of contract used contains detailed figures for the calorific value desired, and limiting percentages for the moisture, ash and sulphur. The contract does not provide for any reduction in price if these standards of value are not preserved in the fuel actually delivered; but it does provide for the total rejection of the fuel in such circumstances.

(To be continued.)

CURRENT LEGAL TOPICS.

Mr. Burns' Pure Food Bill, 1913.

By WILLIAM JAGO.

STATEMENTS are frequently appearing in the lay press, which, when briefly summarised, amount to allegations that articles sold for food are sophisticated to such an extent that—

(1) They do not nourish, or at least have been largely deprived of their nutritive value.

(2) They are injurious to health, and even produce poisonous effects on the consumers.

In consequence, a demand has been made for further legislation on the purity of food. Already there are several such Acts in existence, which are conveniently cited as "The Sale of Food and Drugs Acts, 1875 to 1907." Before considering any proposed further legal enactments, one may profitably inquire as to what powers of control are given by the law as it now stands. The most important operative clauses are those found in the Act of 1875. These provide in effect in the case of articles of food intended for sale, that no ingredient or material shall be added to or incorporated with such articles of food, so as to render them injurious to health. The prohibition in this case is absolute. Further, no person shall sell to the prejudice of the purchaser any article of food which is not of the nature, substance, and quality of the article demanded by such purchaser. To this there is an important exception in the case where any matter or ingredient not injurious to health has been added to the food or drug, because the same is required for the production or preparation thereof as an article of commerce, in a fit state for carriage or consumption, and not fraudulently to increase the bulk, weight, or measure of the food, or conceal the inferior quality thereof. The net is here cast very wide, and one would have said at first sight sufficiently far to amply protect the consumer. Whatever other defects the Food Acts may have, the grosser forms of adulteration are here distinctly prohibited; and are penalised in following sentences. The sale of food which has been deprived of that nutritive value which it should naturally possess in the form demanded by the purchaser, is not a sale of an article of the nature, substance and quality demanded, and is to the prejudice of the purchaser. Any real damage to the interests of the public coming within group (1), above mentioned is thus amply provided for. Assertions are sometimes made that some food manufacturing processes lessen the hypothetical nutritive value of the resultant product; but it must be remembered that the consumer is governed in the purchase of food, not only by its nourishing properties, but also by its appearance and flavour. In cases such as these, the vendor is but the servant of the consumer; and if the latter elects to sacrifice some portion of nutritive value for the enhancement of other qualities he

appreciates more highly, no wrong is done to him by the seller. If there are any cases known of the sale of articles of food which are poisonous in their effects, then at once they may be stopped by proceedings under the section absolutely prohibiting any addition which even renders the article injurious to health, to say nothing of causing it to be poisonous.

Some light may perhaps be thrown on the objects and wishes of those demanding further legislation, by looking at some of the more important actions which have already been fought under these Acts. A typical example of those referred to is that of *Smith v. Wisden*, in which a grocer sold marmalade containing "foreign ingredients as under, starch glucose, 13 per cent." It was argued that this was an addition to the prejudice of the purchaser, but it was decided on appeal to the High Court that the purchaser got an article given to him, which if it was different at all was different in the sense that it was rather better, and therefore that the conviction by the justices must be quashed. This is only one of many instances where what was introduced as a *bonâ fide* attempt at improvement by the manufacturer has been attacked as an adulteration by those administering the law. Other well-known cases are those against two Islington publicans for selling as Irish and Scotch whiskey respectively, spirit which *inter alia* was distilled in a patent still instead of in a pot-still. In this instance there was a conviction. This led to the appointment of a Royal Commission, which arrived at the conclusion that no restriction should be placed on the apparatus used in the distillation of whiskey. Their decision was in effect a reversal of that of the magistrate. The admixture of starch with yeast is very instructive in this connection, because in the earliest development of the compressed yeast industry, the addition of starch was necessary for the production of such yeast as an article of commerce. With the introduction of certain manufacturing improvements, this necessity ceased to exist; but at a previous stage in the history of the industry the necessity for the use of some starch was made the cloak for the addition of unnecessarily large quantities with the object of fraudulently increasing the weight. This is one of the difficulties that arise in the application of the Food and Drugs Acts: something which, when done to a moderate extent, is an improvement, or even a necessity, may also be capable of such immoderate use as to amount to a fraud. This reference to yeast serves as a reminder of the historical fact that about the middle, or slightly later, of the seventeenth century, Parisian bakers invented the use of yeast prepared by an extraneous brewing in the making of bread. Everyone now recognises the immense value of this invention, and yet in the year 1688, the Faculty of Medicine of Paris gravely denounced the use of such yeast in bread making as prejudicial to the health of the people.

It is only in the very nature of things that food manufacturers will be continually endeavouring to introduce improvements in perfectly good faith. And, unfortunately, others will under the same plea try to perpetrate what are really acts of fraud.

Another more conservative section of the community will oppose all innovations, even though they be good, because of the risk of letting in that which is bad. Where the present law is principally defective is in the provision of adequate means for deciding justly and readily the conflicting issues raised by the three classes just referred to. As a guiding principle, the writer suggests that any innovations in food manufacture which are to the ultimate detriment of the consumer should not be permitted; while those which are to his benefit, either directly by improving the quality of the article, or indirectly by lessening the cost of its production, should not only be permitted, but are deserving of every encouragement. Some may perhaps be inclined to look askance at the lessening of cost of production. In fact, the argument is frequently advanced that such is solely to the benefit of the producer and not at all to that of the consumer. Commercially, however, when an article is produced more cheaply, it is almost immediately sold more cheaply, and thus in a very short time the consumer has most if not all the advantage of reduction of cost. Mr. Burns' Bill endeavours apparently to provide means for more readily dealing with some of the difficulties referred to in this paragraph.

The sub-sections 1 and 2 of section 1 of the Bill provide that—"The Local Government Board may, after such inquiry as they think necessary, make regulations defining an article of food in any matter affecting its nature, substance, or quality. If any article of food with respect to which regulations have been so made is demanded by a purchaser, and the article sold does not comply with the regulations, it shall be deemed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1907, to be not of the nature, substance, and quality of the article demanded, and to be sold to him to his prejudice."

Two questions immediately arise:—

(1) In the interests of the public, is it advisable that such regulations be made?

(2) Is the machinery which it is proposed shall be set up the best for the particular purpose?

The powers that it is proposed to take are so wide that it is scarcely possible to say where they may stop. As an example, some two or three years ago, there was a widely-spread agitation in favour of what was called "Standard bread." A manifesto was issued by eight London medical men, in which it was alleged to be "a national necessity that a standard should be fixed for the nutritive value of what is sold as bread." It was also urged therein, that "legislation should be passed making it compulsory that all bread sold as such, should, unless distinctly labelled otherwise, be made from un-adulterated wheat-flour containing at least 80% of the whole wheat, including the germ and semolina." If the present Bill becomes law, and the Local Government Board made a regulation adopting the above definition as the standard for bread, then notwithstanding the fact that over 90% of the bread now made and sold is something different,

every vendor and consumer would have to adopt this impossible standard. If in response to the demand for a loaf of bread, the ordinary article of commerce were supplied without being distinctly labelled otherwise, the sale would be held to be of something not of the nature, substance, and quality of the article demanded by the purchaser, and to be sold to him to his prejudice. Such an interference with the ordinary rules of demand and supply might easily become an intolerable burden to the community. It is doubtful whether the making of regulations is in any case the best solution of this problem, since it is in the nature of regulations to become hard and fast, and thus act as obstacles in the way of legitimate improvement. The invention of yeast again affords an apt illustration. Suppose that it had not as yet been made, and that the Local Government Board proceeded to make regulations as to the manufacture of bread. One of these might conceivably be: "Bread shall be manufactured only from flour, water, salt, and leaven." On the use of separately manufactured yeast being invented, its employment would at once become a contravention of the Food and Drugs Acts, and no question of the merits of yeast could be advanced as a defence to a prosecution.

In the second place, attention must be directed to the proposed machinery. That suggested is "after such inquiry as they [the Local Government Board] think necessary." To this there is the great objection that the Local Government Board is an administrative and executive authority, of which the President is always a political personage, and usually a member of the Government for the time being. In this country, experience has taught us the wisdom of making the wielders of judicial authority an absolutely separate body, and entirely independent of political parties. An alternative course would be the creation of such a tribunal as is frequently referred to as a Court of Reference. The necessities of such a Court are that it should be competent and unbiassed. Judging from other examples it might well consist of a judge not necessarily provided with such generous emoluments as hold in the High Court, and some one or two assessors who should between them possess adequate scientific and commercial knowledge and experience. In cases where the importance of the subject demands it, there should be the same general rights of appeal as exist in other civil cases.

But by whomsoever the inquiry is held, the nature of such inquiry should be definitely provided for by the Bill, and not left to the discretion of the Local Government Board. At the least it should be one at which all parties interested should have the right to be represented. And if the officials of the Board appear for the purpose of asking that certain regulations be made, they should adduce their evidence in open court and subject to the test of cross-examination. The same of course equally applies to parties appearing in opposition.

Other matters of interest appear in the Bill, but exigencies of space forbid their being dealt with in the present article.

PATENT RECORD.

*Abstracts of recent Specifications specially compiled by
MR. JOHN E. RAWORTH, Chartered Patent Agent,
Queen Anne's Chambers, Westminster, S.W.*

15664/12. W. INNES. **Lead Oxide Production.**

A method of producing lead consists in maintaining metallic lead in a molten condition in an oxide pot and stirring it and its dross by means of revolving stirrers whose axes are arranged in positions other than vertical, the stirrers being rotated in the same or in opposite directions and at any desired relative speeds.

16237/12. T. K. IRWIN. **Sewage Treatment.**

In a continuous process for the treatment of sewage the sludge is first mixed with a fixed proportion of yeast heated to a predetermined temperature and then delivered to receptacles in which fermentation and separation of the sludge and effluent take place prior to the treatment of one or both of the separate constituents.

16450/12. E. R. SUTCLIFFE and CUIVRES, MÉTAUX ET PRODUITS CHIMIQUES D'HEMIXEM SOCIÉTÉ ANONYME. **A Method of and Apparatus for Treating Ores, more especially applicable for Roasting Spent or Burned Pyrites and the like.**

19100/12. GENERAL REDUCTION GAS AND BY-PRODUCTS COMPANY. **Coal Gas.**

The process described for continuously treating carbonaceous matter for the production of coal gas consists in introducing sub-divided carbonaceous materials into a continuously rotated chamber, showering the materials in such chamber and heating them out of contact with a heating medium which is hotter at one end of the chamber than the other.

19101/12. GENERAL REDUCTION GAS AND BY-PRODUCTS COMPANY. **Improvements in the Method of and Apparatus for Treating Carbonaceous Materials for the Production of Water Gas.**

21850/12. N. G. A. M. J. CHAMPY and L. P. A. G. CHAMPY. **Storing Explosive Gases.**

A method of storing acetylene dissolved in acetone or other solvent consists in filling the storage receptacles with a finely divided porous material having interstitial spaces of minimum size prepared by the carbonisation of organic substances.

22342/12. R. LANTZSCH. **Purifying water.**

In plant for purifying water and removing the iron contained therein by means of compressed air, the air utilised for the oxidation and precipitation of the dissolved iron is purified before its introduction into the water containers by means of high compression and subsequent expansion.

22590/12. H. SPENCE, W. B. LLEWELLYN and PETER SPENCE & SONS, LTD. **Improvements in the Production of Aluminous Compounds.**

22653/12. W. H. PERKIN, C. WEIZMANN and H. DAVIES. **Improvements in the Manufacture of Halogen Derivatives of Organic Compounds.**

22855/12. P. C. C. ISHERWOOD. **Zinc Lead Ores.**

A process for the recovery of zinc from prepared refractory zinc lead ore consists in leaching the ore under basic conditions with a quantity of sulphuric acid less than

that necessary completely to dissolve the zinc contained therein, and then leaching the partially extracted ore under conditions of high temperature and pressure, with the remainder of the sulphuric acid necessary for the solution of the remainder of the zinc contained in the ore.

16218/13. H. C. WOLTERECK and J. MOELLER. **Zinc Extraction.**

The process of extracting zinc from ores previously roasted consists in treating the finely ground ore with a boiling aqueous solution of a ferrous salt for the purpose of leaching out all zinc contained in such ores

26895/12. J. W. KYNASTON and THE UNITED ALKALI CO., LIMITED. **The Manufacture of Zinc Sulphate from Liquors Obtained by Treatment of Galvanised Iron Scrap, Zinc Residues or the Like with Sulphuric Acid.**

27148/12. J. RUEB. **Tin Smelting.**

A process for the separation of tin from ores and other materials containing tin consists in smelting the material with fluxing or slag forming agents without the addition of material having an oxidising action, but with the addition of iron pyrites, copper pyrites or other sulphides of heavy metals if the material to be treated contains insufficient sulphur, copper or iron to produce a matte containing substantially the whole of the tin.

218/13. GOLDSCHMIDT AKTIENGESellschaft. **Alumino-thermic Welding.**

In aluminothermic welding, there is inserted between the faces of two objects to be welded a piece of metal of a character corresponding to the character of the metal of which the objects are formed and corresponding more or less to the section of the object, the remaining part of the space between the objects being filled up by liquid iron resulting from the aluminothermic reaction.

1181/13. J. W. CHENHALL. **Treatment of Tin Ores.**

2281/13. BERLIN-ANHALTISCHE MASCHINENBAU-AKTIE-GESELLSCHAFT. **Apparatus for Mixing Gases of Different Specific Gravities in Gasholders.**

3313/13. L. PENKALA. **Agglutinant for Manufacturing Agglomerates.**

7161/13. CHEMICAL WORKS, FORMERLY SANDOZ. **Manufacture of a Violet Galloxyaniline Dyestuff and its Leuco-Derivative.**

8190/13. HENKEL & CIE and W. WEBER. **Hydrogen Peroxide.**

This process for the manufacture of hydrogen peroxide consists in causing gaseous oxygen to act continuously under pressure, in the presence of water, on gaseous hydrogen in the presence of suitable hydrogen transmitters, additional hydrogen being admitted as it is used, the solution of hydrogen peroxide constantly drawn off and corresponding amount of water supplied.

9132/13. J. WHITE and J. N. BERTRAM. **Apparatus for Treating Bamboo Stems and Similar Material to Prepare them for Use in the Manufacture of Paper Pulp.**

22909/12. H. M. LESLIE. **Process for the Extraction of Gold and Silver remaining in Iron Ores which have already been treated for the removal of Sulphur, Copper or other Metals.**

22958/12. J. T. ARMSTRONG and J. MORDAN. **Artificial Fuel.**

A process of manufacturing artificial fuel consists in the incorporation of sewage or like sludge in an emulsion of liquid hydrocarbon and a suitable binder.

23451/12. H. R. NASH. **Vulcanising Process.**

A process of vulcanising at atmospheric pressure consists in directly immersing the articles, protected by a suitable wrapping, in a bath of oil contained in an open vessel and electrically heated to vulcanising temperature.

23475/12. C. H. FISCHER. **Tungsten.**

Pure tungstic acid is produced by forming a smelt of powdered tungsten ore and alkali, dissolving out the alkaline tungstate so obtained and precipitating the anhydrous tungstic acid by adding this solution to an acid bath.

23591/12. H. L. SULMAN, H. F. K. PICARD and W. BROADBRIDGE. **Nitrates.**

A process for the extraction of nitrates consists in subjecting the crude material to attrition and classification in a cold saturated circuit liquor and thereafter treating the concentrate in a separate hot liquor circuit for solution and filtration.

25631/12. C. ELLIS. **Improvements in Processes of Cracking Heavy Oils.**25845/12. T. HUGHES, M. RUTHENBERG and G. K. DAVIS. **Distilling Apparatus.**

Apparatus for the distillation of tar or like substances comprises a series of stills each consisting of an inner heated vessel and an outer vessel forming a jacket thereto, the vessels being so connected that the material may pass from one still to the other and fractional distillation take place.

26616/12. I. P. LLWELLYN and PETER SPENCE & SONS, LTD. **Improvements in the Production of Aluminium Sulphate from its Solution.**27525/12. H. LEVINSTEIN, J. BADDILEY and LEVINSTEIN, LTD. **Improvements in the Production of Fast Orange, Red or Brown shades on Vegetable Fibres and Dyestuffs therefor.**27117/12. BADISCHE ANILIN and SODA FABRIK. **Hydrogen.**

In the manufacture of hydrogen by causing carbon monoxide and steam to react in the presence of a hot catalytic agent, the required temperature is produced by combustion in the catalytic chamber of oxygen or air.

3662/13. FARBERWERKE, VORMALS MEISTER LUCIUS and BRÜNING. **Nitrogen.**

In the process of obtaining nitrogen simultaneously with oxides of nitrogen by combustion of ammonia in atmospheric air, the concentration of the ammonia is high, there is no excess of oxygen in the reacting mixture of ammonia and air, and the oxygen is present in a quantity just sufficient for the formation of lower or higher oxides of nitrogen, upon the extraction of which, with or without the co-operation of the water produced by the reaction, pure atmospheric nitrogen is obtained.

5438/13. F. C. W. TIMM. **Process of and Apparatus for Recovering Zinc from Slags, Ores, and other Zinciferous Materials.**6925/13. F. E. ANGLADA. **Repairing Caoutchouc Articles.**

A composition intended for repairing or gumming articles of caoutchouc consists of a solution of caoutchouc in bi-sulphide of carbon mixed with a metallic sulphide, such as antimony penta-sulphide.

7139/13. E. H. STRANGE and H. E. COLEY. **White Lead.**

In the manufacture of white lead, fine threads or hairs of lead, produced by allowing molten lead to issue under hydrostatic pressure through fine perforations on to a cooled travelling metallic surface by which it is solidified, are employed.

7147/13. SOCIÉTÉ L'AIR LIQUIDE. **Hydrogen.**

A process for the manufacture of hydrogen by the partial liquefaction of water gas consists in subjecting the carbon monoxide resulting from the partial liquefaction to a chemical reaction which results in the approximate transformation of it into hydrogen, and adding the hydrogen so obtained to the further quantities of water gas to be treated.

27735/12. BADISCHE ANILIN and SODA FABRIK. **Hydrogen.**

In the manufacture of hydrogen by alternately passing steam over iron at a raised temperature and reducing the oxide formed, porous or spongy iron obtained by embedding an iron ore or iron oxide in carbon and then heating it from the outside, is employed.

29878/12. O. A. WHEELER, E. D. LOEWENTHAL and B. LOEWENTHAL. **Reclaiming Waste Rubber.**

A process of reclaiming waste rubber containing cellulose, consists in treating the cellulose with a solvent and arresting the treatment when the cellulose is coherent and tenacious, and leaving the cellulose in the rubber.

29996/12. M. HAMBURG. **Cattle Food.**

A process of raising the nutritive value of brewery grains and obtaining a food for cattle consists in mixing yeast autolysed at a temperature not exceeding about 60° C. with brewery grains, and removing moisture from the mixture by heating the same at a temperature below that at which the enzymatic properties of the yeast are destroyed.

2848/13. F. GOTHARD. **Cattle Food.**

An animal food for use by itself or combined with other food substances is composed of yeast, hops and commercial peat moss combined to form a meal.

3133/13. F. KAUFLEB. **Improved Manufacture of Acetic Acid Esters of Amyl Alcohol and its Homologues.**7562/13. A. PELLERIN. **Cellulose Filaments.**

In apparatus for the manufacture of filamentous or pellicular cellulose materials by the injection of a solution of cellulose through fine holes into a current of precipitating liquid, the perforated plates for the injection of the solution are arranged in several rings around the wall of the tube through which the precipitating liquid passes and are placed obliquely with relation to said tube in chambers or nozzles formed around said tube in such a manner that a large number of filaments can be formed at the same time in the same current.

7693/13. E. SZASZ. **Steel.** Rapid process of and apparatus for determining and controlling the carbon content of iron steel and the like iron alloys.8530/13. G. CAREW and BRITISH WESTFALITE, LTD. **Explosives.**

An explosive for use in coal mining contains nitrate of ammonium, 58 to 61 parts; nitrate of potassium, 13 to 15 parts; chloride of ammonium, 20 to 22 parts; tri-nitro-toluol, 4 to 6 parts, and moisture, nil to 1 part.

8693/13. E. T. SCHENTZ. **Dyestuff.**

An improved dyestuff consists of a dry mixture of sulphur dye, sulphide of sodium and carbonate of soda with or without an addition of chloride of sodium, the mixture being packed in hermetically closed vessels.

10292/13. BARIUMOXID GESELLSCHAFT MIT BESCHRÄNKTER HAFTUNG. **Hydrogen Peroxide.**

Concentrated stable hydrogen peroxide is manufactured by treating metal peroxides, the metal of which gives difficulty soluble phosphates, with sufficient concentrated phosphoric acid to effect complete decomposition, and separating the solution from the precipitate.

11530/13. **FARBENFABRIKEN, VORMALS FRIEDRICH BAYER & Co. Vulcanising Process.**

A process for the vulcanisation of natural or artificial caoutchouc or caoutchouc-like substances consists in carrying out the vulcanisation in the presence of piperidine or of its homologues.

12376/13. **C. F. DIPPEL. Explosives.**

An explosive compound consists essentially of an anhydrous admixture of potassium chlorate, two parts, white granulated sugar, one part, and denatured alcohol.

14046/13. **GEBRÜDER KELLER, BAUGESCHÄFT, AKTIENGESELLSCHAFT. An Improved Process of and Apparatus for the Continuous Distillation of Tar.**

15581/13. **N. BELJAEFF. Treating Vegetable Fibres.**

A process of treating vegetable fibres consists in subjecting the same to spiritous fermentation, bleaching by means of chlorine or sodium peroxide or other oxygen carrier, subjecting to acid fermentation with acetic, sulphuric or hydrochloric acid and finally bleaching.

15933/13. **DR. BRUNO BECKMANN, CHEMISCHE FABRIK, G.m.b.H. Diethylbromoacetyl Carbamide.**

Diethylbromoacetyl carbamide is produced by reacting with carbamic chloride upon diethylbromoacetamide, either as such or in solution in an indifferent solvent and with the addition of a suitable basic compound.

16470/13. **A. CLEMM. Ammonia Soda Process.**

In the ammonia soda process the resulting solution of ammonium chloride is treated with electrolysed sodium chloride so as to expel the ammonia, the solution of sodium chloride obtained, after being subjected to electrolysis, being usable again to expel ammonia.

17533/13. **FARBWERKE, VORM. MEISTER LUCIUS and BRÜNING. Arsenic-Antimony Compounds.**

Arsenic-antimony compounds are manufactured by treating an aromatic primary arsine with an antimony compound containing the atomic grouping — Sb (Halogen)₂ or — SbO.

ENGINEERING NOTES.

BY R. J. DUNDERDALE, B.A. (CAMB.), A.M.I.C.E.

Refrigeration.

On August 27th of this year *The Times* published a short *résumé* of the position, in an engineering sense, of the refrigerating trade and its applications.

This they did in view of the Refrigerating Congress held in Chicago in September.

As pointed out in that article, food preservation is by far the most extensive and important object to which the process is applied, but when that has been accomplished there are still about 20 important operations in the chemical, engineering, and commercial industry which are indebted to this means for their greater modern efficiency and economy; to mention an example in each case—refining oils, freezing the walls of mine and tunnel borings, and cooling theatres and flats in New York.

As the article further pointed out, this country is somewhat behindhand in the construction of suitable machinery, but this is largely due to the fact that we enjoy a moderately cool climate, and are not exporters of frozen meat to any extent.

All that relates to this country and refrigerating machinery Mr. Lightfoot, in a letter to the *Times Engineer-*

ing Supplement of September 3rd, 1913, vehemently denies. However, his contentions were rather bitingly contradicted in the next week's issue of that supplement by the author of the preceding article.

Mr. Lightfoot contended that the refrigerating machinery made in this country is as well designed as, and possibly better engined than, similar machinery anywhere else. The author of the *Times Engineering Supplement* article contended that while the machinery is only moderate, the power supply or driving engines cover by their excellences any deficiencies in the refrigerating plant proper.

The moral from a refrigerator's and from a chemical engineer's point of view seems to be to get the best refrigerating (or chemical) plant for his purpose he can, and then to use a really efficient and economic drive. This latter point is really exceedingly important, for nothing mounts up so steadily as a coal bill, and a great many good, or at any rate fairly good, special plants are made to appear poor, owing to the rather off-hand manner in which this absolutely essential adjunct (the power supply) is treated.

Tar and Metallurgy.

A paper on this subject was read at the autumn meeting of the Iron and Steel Institute, which opened on September 1st at Brussels. The author was M. Geversorbau of Liège. The author began by expressing his opinion that the time^e had now come for removing the site of the by-product coke oven from the near neighbourhood of the colliery to that of the ironworks. The chief point in favour of this is the utilisation of the hot gases in the open-hearth process. As a source of cheap power, a point also emphasised, the gas can doubtless be almost equally well employed at either place. The points he made with regard to tar and pitch apply more to Belgian practice than to English. In Belgium most interest centres (as regards the by-products) in the initial tar and the final pitch; in this country a greater interest is taken (than is the case in Belgium) in the products intermediate between these two, and hence the Cava process of treating the coke-oven tar is not of as great interest to the coke-oven user here as it would be in Belgium.

Nevertheless, as the tendency here is to continuous processes in tar distillation of any kind, a rough *résumé* of the outlines of the Cava method may be of interest to those distilling tar, though their chief aim in this country is not usually the production of pitch of varying hardnesses.

In the Cava treatment the tar enters at one end of a horizontal boiler retort, 20 ft. long by about 5 ft. diameter, and this is kept about half full, the tar slowly travelling from the tar to the pitch end, and being briskly agitated by a paddle stirrer along its length and exposed to a fairly rapid current of air. At the pitching end the mass leaves through a spiral cooler at a temperature of 200° C. to 250° C., according to the hardness required in the cooled pitch.

It is hardly necessary to point out that, as described above, there is a very considerable waste of the volatile creosote in the tar on its path to pitching, but there seems to be no particular reason why a set of vacuum intakes should not be fitted along the top of the retort, so as to afford a crude fractionation, instead of employing the wasteful air current.

By such an alteration the pitch would usually be of a harder nature at the outlet—but to suitably soften any desired quantity of this pitch (which is a frequent operation now in this country) would probably be far more profitable than to lose all or most of the intermediate creosotes, as seems to be now the case.

The natural claims on behalf of the retort are, of course, its continuity, uniform heating, and hence much greater life than is common with the average tar still or retort.

Tar as Protective Covering for Iron.

In the *Times Engineering Supplement* for September 17th there was a short note on some experiments by the French military engineers at Brest.

Over a year ago they coated some iron scantlings with a mixture of tar and quicklime, and at the date of their most recent examination no trace of corrosion was observable under this coating.

The note pointed out that the coating, a mixture of tar and powdered CaO. in the proportion of 2 of tar to 1 of CaO., was laid at a temperature of 120° F. on the iron over a coating of red lead already there.

The point that the tar and CaO. was to be laid over red lead was emphasised, and it was suggested that the CaO. was especially useful in that neighbourhood, because

there is a "brackish atmosphere" there—whatever that may be.

Some reasons for the use of the various ingredients in this protective coat might have been given. All these ingredients are well known, and two of them very well known as preservatives of structural iron. There is no magic nowadays, and the idea underlying this particular "paint" would be interesting. We are not questioning its soundness. Why are coats of red lead and tar plus CaO. necessary? Many coatings of paint are now usually regarded as disadvantageous.

Also what is actually the function of the quicklime? Does it assist in the certain and absolute dehydration of the tar, or act as a buffer state between the iron and the outer "brackishness," combining more readily with the latter than the iron would?

If this "paint" is better than any of the more usual coverings it has plainly a splendid field of use, which it would the more rapidly fill if its *raison d'être* were made perfectly clear.

REVIEWS OF BOOKS.

"PRACTICAL MEASUREMENTS IN RADIO-ACTIVITY." By W. Makower and H. Geiger. LONGMANS, GREEN & Co., London, 1912. Pages 151 + vi, including Appendices and Index. Chapters IX., with 61 Illustrations. Price 5/- net.

A NUMBER of experiments, designed by Professor Rutherford for the Honours course in physics at the Manchester University, are described in this text-book; and it is held that it is possible to illustrate the principles of radio-activity by experiments made with simple apparatus and small quantities of radio-active materials. It is also claimed that this work is an attempt to meet the requirement of those engaged in original investigation, as well as acting as a laboratory text-book.

The subject-matter is contained in nine chapters, which deal with such subjects as ionisation of gases, alpha rays, beta and gamma rays, radio-active recoil, and radio-active transformations. Other chapters deal with the separation of radio-active substances, standard measurements, electroscopes, etc. The book is well illustrated by a set of diagrams and curves, and will certainly be found of great value to the advanced student and others interested in this subject.

"THE TESTING OF WOOD PULP." A Practical Handbook for the Pulp and Paper Trades. By R. W. Sindall and W. Bacon. MARCHANT, SINGER & Co., London, 1912. Pages 148, including Index and 3 Appendices. Sections IX, with numerous Illustrations. Price 5/- net.

This work is divided into two parts, dealing respectively with moisture in wood pulp and the bleaching qualities of wood pulp. An appendix deals with bleaching powder, bleach liquors, and oxidation of cellulose. The methods of sampling are described, also the apparatus used for determining moisture and colour. When dealing with

the latter the question of a "standard" is considered. This work contains a great deal of useful information, and will be welcomed by all chemists interested in the subject.

"INORGANIC CHEMISTRY." By H. P. Cady. HILL PUBLISHING Co., LTD., London, 1912. Pages 629 + vii, including Index. Chapters XXXI., with 42 Illustrations and Frontispiece. Price 10/6 net.

The author believes in teaching qualitative analysis from the point of view of mass action and electrolytic dissociation. The work is divided into thirty-one chapters, and the order of treatment is much that adopted by custom in general text-books. It is obviously written for students, and from this point of view deserves attention in this country.

"CHEMISTRY OF RUBBER." By E. D. Porritt. GURNEY AND JACKSON, London, 1913. Pages 96 + vi, with Bibliography and Index. Sections VI. Price 1/6 net.

This monograph is written by an industrial chemist of considerable standing in the rubber industry, and, in an elementary way, gives a satisfactory account of the present state of the chemistry of rubber. Its appearance is opportune, on account of the great interest taken in the subject of the value of the plantation product by the manufacturer.

The final chapter deals with synthetic caoutchouc and the preparation of isoprene. It gives a very interesting *résumé* of the work done in this direction by Harries and others. With rubber at its present price there seems little chance of the synthetic product coming on the market.

"LABORATORY TEXT-BOOK OF CHEMISTRY." Part I. By V. Seymour Bryant. J. & A. CHURCHILL, London, 1913. Pages 246 + vi. Chapters IX. Price 4/- net.

The author is an assistant master at Wellington College, and this text-book is written for school

purposes. The work is divided into nine chapters, which deal with such matters as mixtures and their separations, water, hydrogen, oxygen, chemical laws, the atmosphere, and nitrogen and its simpler compounds. The arrangement of the text and subject-matter is novel, and no doubt will serve a useful purpose.

"THE CHEMICAL CONSTITUTION OF THE PROTEINS." By R. H. A. Plimmer. Part II. LONGMANS, GREEN & Co., LTD., London, 1913. Pages 107 + xii, including Bibliography and Index. Price 3/6 net.

Although no startling discovery has been made or recorded in this second edition, this volume deals with recent detail work of Fischer, Abderhalden, Osborne, Van Slyke, Levene and others. The subject-matter has been rearranged and gives a more complete idea of the problem of the synthesis, structure, configuration and properties of the polypeptides. The volume also deals with the action of enzymes and the study of their applications. A very complete bibliography is included, and it is hardly necessary to point out that this monograph will certainly be referred to with ever-increasing confidence by all those interested in bio-chemistry.

BOOKS, ETC., RECEIVED.

"Carbon Dioxide Snow; Its Therapeutic Uses," by J. Hall-Edwards. Simpkin, Marshall, Hamilton, Kent & Co., Ltd., London, 1913. Pages 78 + iv, with 21 Illustrations. Price 3/6.

"Underground Waters for Commercial Purposes," by Frank L. Rector. Chapman & Hall, Ltd., London, 1913. Pages 98 + iv, with Appendix and Bibliography. Chapters X., with 8 Illustrations. Price 4/6 net.

"Handbook on Sanitation." Manual of Theoretical and Practical Sanitation, by George M. Price. Third Edition. Chapman & Hall, Ltd., London, 1913. Pages 353 + iv, with Index. Divided into 3 Parts with XXVII. Chapters and 24 Illustrations. Price 6/6 net.

"A Dictionary of Applied Chemistry," by Sir Edward Thorpe. Vol. V., Sodium-Z. Longmans, Green & Co., London, 1913. Revised and Enlarged. Pages 830 + viii. Numerous Illustrations. Price 45/- net.

"A Text-book of Quantitative Chemical Analysis," by Alexander Charles Cumming, and Sydney Alexander Kay. Gurney & Jackson, London, 1913. Pages 382 + xi, with Appendix and Indices. Parts X., with 96 Illustrations. Price 7/6 net.

"Chemistry Inorganic and Organic," with Experiments, by Charles Loudon Bloxam. Tenth Edition. Rewritten and Revised by Arthur G. Bloxam and S. Judd Lewis. J. & A. Churchill, London, 1913. Pages 878 + xi, with Index and 313 Illustrations. Price 21/- net.

"Practical Science for Engineering Students," by H. Stanley. Methuen & Co., Ltd., London, 1913. Pages 162 + vi, with Index and Appendix. Parts V., with 92 Illustrations. Price 3/-.

"The Progress of Scientific Chemistry in our Own Times," by Sir William A. Tilden. Second Edition. Longmans, Green & Co., London, 1913. Pages 366 + x, with Index and Biography. Chapters XI. Price 7/6 net.

"Coal Tar Distillation, and working up of Tar Products," by A. R. Warnes. John Allan & Co., London, 1913. Pages 185 + xii, with Appendix and Index. Chapters XVIII. with 65 Illustrations. Price 7/6 net.

"Monthly Statement of Coal-Mine Accidents in the United States; January, February, and March, 1913." Compiled by Albert H. Fay. Bureau of Mines, Washington, U.S.A., 1913. Pages 11, with 6 Tables.

"Proposed Regulations for the Drilling of Gas and Oil Wells, with Comments thereon," by O. P. Hood and A. G. Heggem. Technical Paper 53, Bureau of Mines, Washington, U.S.A., 1913. Pages 28, with 2 Illustrations.

"Permissible Explosives," tested prior to March 1st, 1913, by Clarence Hall. Technical Paper 52, Bureau of Mines, Washington, U.S.A., 1913. Pages 11 with 2 Tables.

"Report of the Mine Inspector for the Territory of Alaska," for the Fiscal Year ended June 30th, 1912. Government Printing Office, Washington, U.S.A., 1913. Pages 24 with 9 Tables.

"Wastes in the Production and Utilisation of Natural Gas and Means for Their Prevention," by Ralph Arnold and Frederick G. Clapp. Technical Paper 38, Bureau of Mines, Washington, U.S.A., 1913. Pages 29.

"The Selection of Explosives Used in Engineering and Mining Operations," by Clarence Hall and Spencer P. Howell. Bulletin 48, Bureau of Mines, Washington, U.S.A., 1913. Pages 50, with 6 Figures and 3 Plates.

"Transactions of the Faraday Society." July, Vol. IX., Parts I. and II. Published by the Faraday Society, London, 1913. Pages 202, with Illustrations. Price 15/- net.

The Bradford Technical College. Calendar, 1913-14. Pages 149. Bradford.

"Coal-Mine Accidents in the United States, 1896-1912," compiled by Frederick W. Horton. Technical Paper 48, Bureau of Mines, Washington, U.S.A., 1913. Pages 74, with 10 Figures and 42 Tables.

"National Mine-Rescue and First-Aid Conference, Pittsburgh, Pa., September 23-26, 1912," by Herbert M. Wilson. Bulletin 62, Bureau of Mines, Washington, U.S.A., 1913. Pages 74.

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COMMERCIAL AND TRADE REVIEW.

GENERAL NOTES.

Cyanide from Beet Sugar Waste.

An American technical journal draws attention to the fact that the removal of a 12½% *ad valorem* protective duty on imports of potassium cyanide will seriously affect the home manufacturer. The largest of them, when combating the proposal to place the article on the free list, recently stated that 5,000 tons of sodium cyanide were manufactured in the United States in 1912. Chemical manufacturing in America undoubtedly suffers by comparison with the much older and more highly developed industry in Europe, particularly in Germany. The German manufacture of alkali cyanide as a by-product from beet-sugar molasses is a case in point.

It appears that beet-sugar molasses contains about 5% potash and 2% nitrogen. If the sucrose is precipitated and removed, the residue becomes a concentrate of potash and nitrogenous materials, and it is this residue, molasses "schlempe" which the Germans convert partly into alkali cyanide. The residue is distilled at about 400° C., yielding gaseous compounds of nitrogen which, on being heated to about 1,000° C., synthesise ammonium cyanide. This is decomposed by sulphuric acid, forming ammonium sulphate and hydro-cyanic acid, the latter being then absorbed in sodium hydroxide. The quantity of sodium cyanide thus produced annually in Germany approximates 5,000 tons, which find a market abroad.

Germany's Trade in Chemicals.

If the foreign trade returns are to be accepted as a guide the chemical industry in Germany continues to develop in a remarkable degree. The figures for the first half of the year set up a new record in chemical exports. The most striking increases are shown in the section devoted to dyes and colours. Synthetic indigo has been exported in immensely larger quantities than at any other time in former years, and this product heads the export list of German chemicals. The export value of synthetic indigo increased from about 18½ million marks last year to 27½ million marks during the first six months of the present year. The colour manufactories may safely be regarded as representative of the German chemical wholesale trade, and they also take the foremost place from the financial point of view. Everything points to a further extension of the industry and a continuance of the large export trade.

A New Essential Oil.

In a communication recently made to the Royal Society of New South Wales a new essential oil is mentioned. It is derived from a new species of *Prostanthera cineolifera*. The green stalks yielded 0.71% of oil of no distinctive odour, but in which the odour of eucalyptus could be traced. The crude oil had the following character: specific gravity, 0.920; refractive index, 1.4711 at 22°, solubility in 70% alcohol 1 in 1.7. Phenols were removed by means of caustic soda, and aldehydes by means of bisulphite of soda solution, and the resulting oil was of pale colour. It was acetylated

in the usual manner, and the esterified oil had a distinct odour of geranyl acetate, the saponification value of the acetylated oil being 34.2. Both free geraniol and geranyl acetate are present in the oil. The total phenols present amounted to 0.65% and consisted of both thymol and carvacrol. The aldehyde was present to the extent of only 0.142%, and had the odour of cumic aldehyde. A phenyl-hydrazone was prepared from the small quantity of aldehyde available, and was found to melt sharply at 126—127°. The aldehyde was therefore cumic aldehyde. On fractionation, the eucalyptol accumulated in the first two fractions, boiling between 167°—204°, and was determined by the resorcinol method. It was thus found to amount to 61%. The unabsorbed portions were separated and examined, and found to consist almost entirely of pinene, but a little cymene was also found to be present.

Potash Propaganda in Russia.

In the course of the next month the management of the Potash Syndicate are arranging a series of conferences at Moscow with the representatives of the Russian Government and agricultural corporations, with the object of extending the potash propaganda in that country. Last year the importation of pure K₂O potash into Russia amounted to 523,000 quintals only. If it is considered that Germany consumes about 5,300,000 quintals per annum, and the United States 2,360,000 quintals, one can easily estimate the immense possibilities for increasing the consumption in Russia with its enormous agricultural territory waiting to be opened up.

The Japanese Competition in the Indian Match Market.

British India is the chief market of the Japanese match exporter. When the Indian Government prohibited the use of sulphur matches after July 1st of this year, the Japanese manufacturers believed that they would be able to monopolise the market. But their hopes have not been realised, as the European makers seized their opportunity and began shipping great quantities of non-sulphurous matches to India. There is an intention to take up the general manufacture of these matches in Japan in order to oust the European competitors from the Indian market.

Natural and Synthetic Dyes in India.

Imports of dyeing and tanning substances into Bombay during the fiscal year ending March 31st recorded a marked growth in value. Aniline and alizarin dyes account for 80% of this trade, both articles showing a distinct recovery from the decline in the fiscal year 1911-12. Imports of indigo, principally from Germany, were valued at £51,082. Bombay is the principal port of entry for India's purchases of aniline dyes, about 76% of the total imports being received here. In connection with dyeing in India—at one time a most important industry—some changes have taken place of late years. The Bombay Administrative Report states that there are now sixteen dye works in the Bombay

Presidency, giving employment to 14,000 people. The old castes of dyers, the Rangaries, appear to have offered violent opposition, but the introduction of cheap aniline and alizarin dyes has thrown the industry open to all who care to take it up. Dyers are now scattered over the whole Presidency and may be found wherever hand-loom weavers are settled. It has resulted in the trade becoming local, goods being rarely sent from one place to another to be dyed. For red colours, alizarin dyes, mixed with the powdered flowers of the dhauri tree, are used. In dyeing cotton, aniline dyes are taking the place of the tumeric plant. Black is obtained from imported copperas, and blue from indigo.

The Russian Chemical Industry.

Although the artificial fertiliser industry in Russia is gradually developing the rate of progress was hardly as rapid as one might have expected in view of the development which has simultaneously taken place in other branches of the chemical industry. The home production of artificial fertilisers is still quite out of proportion to the great demand, as the growing imports tend to prove.

It has often created surprise that the Russian production of super-phosphates has not advanced more rapidly, as there is no lack of good chemists in Russia and the country possesses great natural resources. It appears, however, that in the west and north-west of Russia, where the chief production and consumption of super-phosphates takes place, the raw materials are not present, and the factories are obliged to use imported material. Moreover, the competition from Germany and Austria is so great that the Russian producers are in a very difficult position. This may partly explain the slow progress of the super-phosphate industry and the increasing importation. The Government is carrying out experiments with the production of super-phosphates with local, though poor phosphorites. The results are said to have been satisfactory, and it is, therefore, quite possible that the future may see a more rapid advancement of the industry than the past.

CONSULAR REPORTS.

Chemical Trade of Milan.

The British Consul at Milan states in his report on Commerce and Industry of his district that after the crisis which the Union of Manufacturers of Chemical Manures went through three years ago, the situation improved in 1912. An understanding among producers in the north of Italy rendered competition less keen, and the results in 1912 appear to have been satisfactory. The manufacturers of hygienic and pharmaceutical products had a profitable year owing to supplies for the war in Tripoli and for replenishing depôts.

The Hanover Potash Trade.

According to a British Consular report the Hanover potash trade was flourishing during 1912, in spite of a great number of new ventures. The effect of these on the industry was counteracted by the very large exports to the United States. The demand for Austria-Hungary has shrunk considerably, owing to the Balkan troubles. For the first half of 1912 the total production was 609,000 tons, compared with 573,000 tons in 1911. The following data

are supplied as to the hours of employment and rate of wages in the mining district of Clausthal: 16,867 and 16,548 tons were raised respectively in the first and second quarters of 1912, the work time being a little more than seven hours a day, average wages 4s. 11d. per day, compared with 4s. 9d. in 1911.

MARKET REPORTS.

LONDON.—In sympathy with many other markets which have recently experienced a diminution of activity, the trade in chemicals has also slackened off considerably. The export figures for the last month show a further decline of the values of chemicals, drugs, dyes, and colours, whereas the imports of the same materials have increased during that period, the total value of the exports amounting to £1,829,969 compared with £1,851,059 in October, 1912, and the value of the imports rising from £1,126,491 to £1,219,637.

The home trade in chemicals is considered very unsatisfactory, and what is worse, the future does not seem to hold out any promise of an early revival. The difficulties in the cotton industry and the probability of extended short time working throughout Lancashire, acts detrimentally on the trade in textile chemicals which has constantly been gaining in importance during the last few years and threatens now to experience a set-back.

The fertiliser trade is lacking in life and activity. Nitrate of soda shows considerable weakness owing to the prospects for abundant supplies during next season, and very poor demand for prompt delivery. The present reduced price is 10s. 4½d. for ordinary and 10s. 10½d. for refined quality. Sulphate of ammonia is also favouring buyers who delay their operations in the expectation of falling prices. The export demand is very disappointing, although the shipments continue on a large scale. The October exports of sulphate of ammonia amounted to 30,580 tons, valued at £408,971, against 24,085 tons or £343,963 during the same month of last year. The general position of the market does not justify the expectation of a notable improvement in the near future, although the producers seem to think otherwise, judging by the premium which is asked for forward delivery. Gray 25% quality, London prompt, is quoted at £12 5s. per ton. The pitch market does not present any new features. The actual business is still exceedingly moderate owing to the difference of opinion between buyers and sellers. The latter derive some encouragement from the numerous inquiries which are constantly being received, as well as the smallness of stocks. As the greater part of the shipping season is still before us, there is no reason to assume that the prices will continue to disappoint the makers. The shipments of pitch during October were sufficiently large to strengthen the market, amounting to 42,683 tons against 36,595 tons last year. The nominal quotation for pitch is 41—44s. Benzols enjoy continued good attention, and the position of the makers is very strong. The consumption for motor purposes is growing visibly which seems to guarantee an increasing home demand, while the export trade has also shown great progress. Fifty per cent. benzol prompt is held at 1s., and 90% quality at 1s. 2d. per gallon. Creosote is characterised by great activity and firm tendency. Some makers do not sell under 3½d. per gallon, though some are prepared to accept 3½d. Carbolic acid is flat and neglected at 1s. 0½d. per gallon for 60% quality, East Coast and West Coast prompt.

LIVERPOOL.—The chemical market has been quiet and uninteresting. The prices of the most important articles favour buyers. Sulphate of copper has considerably declined without causing increased demand. Some of the special brands are inquired for, but the general condition is very depressed, and the reports from the Continent are not encouraging. Caustic soda suffers from increasing stocks, and free offering.

MANCHESTER.—So far as heavy chemicals are concerned our market is rather featureless and complaints of sluggish trade have become more numerous. In alkalis most of the principal contracts have been booked for the current twelve months, although at somewhat lower prices than last year. Tartaric acid is in poor demand, yet there is difficulty in getting deliveries from makers. In white powdered arsenic there is a slightly better demand to report.

FINANCIAL NOTES.

It is announced that the shareholders of the Castner Kellner Alkali Co. are to receive a substantial bonus, as well as a final dividend of $13\frac{1}{2}\%$, making $22\frac{1}{2}\%$ for the year. The bonus will take the form of 10s. per share.

The Dunlop Rubber Co. have £490,000 invested in rubber estates, including a new purchase, amounting to £20,000 tapping well over 250,000 trees. The rubber harvested this year exceeds last year's crop by 350%, and has shown substantial profits, which are, however, being invested in the further development of the estates. Planters have not given the company a product which equals Para rubber, but the company on its own estates has produced a satisfactory product by close co-operation between the estate and mill and the use of improved methods of treatment.

The South Durham Steel and Iron Co. show an increased profit of £302,255, against £210,733 for last year. A 25% dividend is paid, and £100,000 put to depreciation account, against £50,000 for last year; £50,000 is put to reserve.

Ilford, Ltd. again pays 6% on its ordinary shares. The report for the year ended October 31st shows a net profit, after making allowance for depreciation and provision for doubtful debts, of £32,762, to which has to be added £6,012 brought forward from last year. After paying the dividend on the 6 per cent. preference shares, a balance of £27,374 remains. £10,000 of this is set aside for writing down goodwill, investments, etc., while a dividend of 6% on the ordinary accounts for £11,400, leaving £5,974, which sum is carried forward.

TRADE ITEMS.

Messrs. George Cradock & Co., Ltd., of Wakefield, issue particulars of their lock coil wire rope suitable for sinking, winding conductors, and aerial ropeways. These are claimed to be exceedingly flexible and of special utility for sinking without guides, or winding in deep shafts.

Messrs. Heathman & Co., of Parson's Green, Fulham, London, S.W., issue particulars of their "Express" Fire King Engine, and Chemical Extinguisher, which range in prices up to £36. The cylinders contain 20 gallons each, and are mounted on a rigid carriage. Sixty feet of hose, in two 30-ft. sections, are included.

We have received from E. Schmatolla, of 150, Nassau Street, New York, particulars of a 10-ton standard lime kiln working on natural draft, and operated by a producer gas furnace attached. The metal workings weigh 30,000 lbs., and it is claimed that these can be erected under ordinary supervision.

Messrs. W. H. Keys, Ltd., of West Bromwich, issue particulars of "Lignolite" used for the protection of timber, against the ravages of white ants, decay, fungus, etc. It is claimed that 1 gallon will effectively saturate 200 or 300 sq. ft., and that wood working so treated can then be painted over in the ordinary manner. This firm also are manufacturers of paint, varnish, disinfectants, burning and lubricating oils, marine glue, etc.

The Oil Well Supply Co., of Pittsburgh, U.S.A., and Dashwood House, London, send an illustrated pamphlet of standard cable outfit for drilling or boring deep wells, for oil, gas, water, or other purposes. It is stated that their works and factories cover 74 acres, and they are the oldest and largest manufacturers of well-drilling plant, which they are prepared to furnish under the conditions present in any part of the world.

SHARE LIST.

Name of Company.	November 24th		October 24th.	
Alby United Carbide	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Ditto. Pref.	3 $\frac{1}{2}$	1 $\frac{1}{2}$	3 $\frac{1}{2}$	1 $\frac{1}{2}$
Associated Portland Cement. (10)	6	6 $\frac{1}{2}$	6 $\frac{1}{2}$	6 $\frac{1}{2}$ xd
Ditto. Pref. (10)	8 $\frac{1}{8}$	8 $\frac{1}{8}$	8 $\frac{1}{8}$	8 $\frac{1}{8}$
Babcock-Wilcox. Ord. ..	2 $\frac{1}{8}$	3	2 $\frac{1}{8}$	3xd.
Ditto. Pref.	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Bell's United Asbestos	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Bleachers' Association. Ord. ..	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Ditto. Pref.	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Borax Consolidated. Pfd. (5) ..	5 $\frac{1}{8}$	5 $\frac{1}{8}$	5 $\frac{1}{8}$	5 $\frac{1}{8}$
Ditto. Defd.	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	2
Ditto. Pref. (10)	11 $\frac{1}{8}$	11 $\frac{1}{8}$	11 $\frac{1}{8}$	12
Bradford Dyers	3 $\frac{1}{8}$	1 $\frac{1}{8}$	1	1 $\frac{1}{8}$
Ditto. Pref.	1	1 $\frac{1}{8}$	1	1 $\frac{1}{8}$
British Oil and Cake. Ord. ..	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Brunner Mond. Ord.	4 $\frac{1}{8}$	4 $\frac{1}{8}$ xd.	4 $\frac{1}{8}$	4 $\frac{1}{8}$
Ditto. 7% Pref. (10)	14 $\frac{1}{8}$	15 $\frac{1}{8}$ xd.	14 $\frac{1}{8}$	15 $\frac{1}{8}$
Bryant and May. Pref.	2 $\frac{1}{8}$	2 $\frac{1}{8}$	2 $\frac{1}{8}$	2 $\frac{1}{8}$
Calico Printers	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Ditto. Pref.	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Castner Kellner	31 $\frac{1}{8}$	31 $\frac{1}{8}$	31 $\frac{1}{8}$	31 $\frac{1}{8}$
Commercial Salt. (2/-)	8/-	8/6	8/-	8/6
Crossley & Sons. (2)	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	2
Ditto. 5% Pref.	4 $\frac{1}{8}$	5	4 $\frac{1}{8}$	5
Eastman Kodak. (\$100)	480	530xd	530	570
Eley Brothers	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Fraser and Chalmers. (£3)	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Gas Light and Coke. (S.)	102	104	100	102
Ditto. 4% Pref. (S)	93	98	93	96
Greenwich Lino. (1)	3 $\frac{1}{8}$	3 $\frac{1}{8}$	3 $\frac{1}{8}$	3 $\frac{1}{8}$
Harrison and Crossfeld. Pref. ..	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Imperial Continental. (S)	160	165xd.	163	168
Ditto. 3 $\frac{1}{2}$ % Debenture (S) ..	83 $\frac{1}{2}$	85 $\frac{1}{2}$	83 $\frac{1}{2}$	85 $\frac{1}{2}$
India Rubber Co. (10)	13	14	13 $\frac{1}{2}$	14 $\frac{1}{2}$
International Salt	6/-	6/6	7/6	8/6
Ditto. Pref. (5/6 pd.)	2 $\frac{1}{8}$	2 $\frac{1}{8}$	2 $\frac{1}{8}$	2 $\frac{1}{8}$ pm.
Lever Brothers. 1st Pref. (10) ..	10 $\frac{1}{8}$	11 $\frac{1}{8}$	10 $\frac{1}{8}$	11 $\frac{1}{8}$
Lister & Co. Ord.	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Mappin & Webb. Ord.	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Neuch'tel' Asphalt. (10/-)	9 $\frac{1}{8}$	9 $\frac{1}{8}$	9 $\frac{1}{8}$	9 $\frac{1}{8}$ xd
Nobel Dynamite. (10)	16 $\frac{1}{8}$	17 $\frac{1}{8}$	12 $\frac{1}{8}$	17 $\frac{1}{8}$
Ditto. Bearer (10)	16 $\frac{1}{8}$	17 $\frac{1}{8}$	16 $\frac{1}{8}$	17 $\frac{1}{8}$
Ditto. 5% Pref. (10)	10 $\frac{1}{8}$	11 $\frac{1}{8}$	11	12
Pears, A. and F. Ord.	13 $\frac{1}{8}$	14 $\frac{1}{8}$	13 $\frac{1}{8}$	14 $\frac{1}{8}$
Ditto. 6% Pref. (10)	12 $\frac{1}{8}$	12 $\frac{1}{8}$	12	12 $\frac{1}{8}$
Price's Candle. (16)	35	37	36	38
Rosario. (5)	8 $\frac{1}{8}$	8 $\frac{1}{8}$	8 $\frac{1}{8}$	9 $\frac{1}{8}$
Salt Union. (4)	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
South Metropolitan 4% Standard (S)	108	110	108	110
Ditto. 3% Debenture (S)	72	74	73	75
United Alkali. (10)	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Ditto. Pref. (10)	7 $\frac{1}{8}$	7 $\frac{1}{8}$	8 $\frac{1}{8}$	8 $\frac{1}{8}$
Val de Travers	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$ xd

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